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# An Investigation of Captive Florida Manatee (*Trichecus manatus latirostris*) Behavior and Social Interactions

Jennifer Sadler Young

# AN INVESTIGATION OF CAPTIVE FLORIDA MANATEE (TRICHECUS MANATUS LATIROSTRIS) BEHAVIOR AND SOCIAL INTERACTIONS

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# AN INVESTIGATION OF CAPTIVE FLORIDA MANATEE (*TRICHECUS MANATUS LATIROSTRIS*) BEHAVIOR AND SOCIAL INTERACTIONS

A Thesis

Presented to

the College of Graduate Studies of

Georgia Southern University

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In Partial Fulfillment

of the Requirements for the Degree

Master's of Science

In the Department of Biology

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by

Jennifer Sadler Young

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To the Graduate School:

This thesis, entitled "An Investigation of Captive Florida Manatee Behavior and Social Interactions," and written by Jennifer Sadler Young is presented to the College of Graduate Studies of Georgia Southern University. I recommend that it be accepted in partial fulfillment of the requirements for the Master's Degree in Biology.

Bruce A. Schulte, Supervising Committee Chair

We have reviewed this thesis
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# Curriculum Vitae

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## ABSTRACT

## AN INVESTIGATION OF CAPTIVE FLORIDA MANATEE BEHAVIOR AND SOCIAL INTERACTIONS

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Human impacts such as pollution, habitat alteration, and boating have caused many injuries and deaths of the Florida manatee, *Trichechus manatus latirostris*. Rehabilitation centers have been established in Florida to help return sick or injured manatees back to the wild. Manatees that are released back to the wild after undergoing rehabilitation in captivity might lose some of their abilities to survive in the wild. A factor that might alter behavior in captive individuals was examined by determining if length of time spent in captivity influenced the behavior of manatees during rehabilitation. Even though all facilities follow similar guidelines, invariable differences exist at separate facilities because of housing conditions and management protocol. Differences in facilities, sex, and seasons also were examined. To determine if these

factors influenced behavioral patterns, thirty-one manatees at six facilities during summer 2000 and twenty-seven manatees at five facilities during winter 2001 were observed.

Major behaviors (swim, feed, inactive and miscellaneous) were recorded once a minute for 180 minutes before, during and after a feeding period over three continuous days. No major differences in the behavior of captive manatees were found with facilities, sex, or season. Hence, the entire captive manatee population sampled was examined to determine if length of time spent in captivity influenced behavior. Duration of time in captivity was expected to show significant differences because the longer an animal remains in captivity, the more its behavior is likely to be altered. However, length of time spent in captivity was not found to influence behavior. This study suggests that length of time spent in captivity may not be an important factor when determining if an animal is releasable or not.

The second part of this study examined the social interactions of captive manatees during rehabilitation. Conflicts and aggression can become heightened in crowded conditions potentially creating competition over resources such as food, mates or space. Resolving conflict can occur when individuals leave a particular situation, defend territories, form small closely bonded groups through affiliation, or establish dominance hierarchies. Therefore, the objectives were to examine the number and type of agonistic and affiliative encounters, as well as determine if individuals within facilities developed frequent associations with certain manatees. Twenty manatees at four

facilities were observed during winter 2001. All agonistic and affiliative encounters were recorded between individuals continuously for 180 minutes before, during, and after a feeding period for three continuous days. A total of 228 encounters were recorded, yet only ten interactions were aggressive. Sender-receiver tables were constructed based on affiliative encounters between animals at separate facilities. Close bonding was observed between certain manatees at all facilities. The presence of social interacting and close association in captive manatees may be a way to prevent conflict in close confines, which suggests that manatees in captivity most likely acclimate to their new environment well and may be more social than previously thought.

# TABLE OF CONTENTS

**TABLE OF CONTENTS (CONTINUED)** Page

## LIST OF TABLES

## LIST OF FIGURES

## Chapter I

## Background

Human impact on the natural environment is directly related to human population growth and resource use. Pollution, habitat loss, and direct consumption are major factors in the historic and current decrease of wild populations in terrestrial and aquatic environments (Baur et al. 1999). One short-term response to direct injury of animals from human actions is the rescue and rehabilitation of unhealthy animals. Usually, rehabilitation serves more as an ethical responsibility than a practical assistance to population stability, especially for marine animals. However, rehabilitation of injured Florida manatees (*Trichechus manatus latirostris*), a subspecies of the West Indian manatee (Family Sirenidae), may increase population growth as well as enhance public awareness about the manatee's plight (Reynolds 1999). Manatee populations are considered low with estimates over the past decade ranging between 2500-3200 animals (Garrott et al. 1994, Marmontel et al. 1997, Lefebvre 2001). Rates of injury from boats and pollution are high compared to the population size, so rehabilitation can have important implications for population stability (Wilkinson and Worthy 1999). Furthermore, manatees are one of the few animals exhibited to the public in zoos and aquariums during the rehabilitation process. Hence, the public can witness the direct impacts of their actions on the environment and the negative consequences on an endangered species.

The Florida manatee is at risk from many environmental and human impacts. Environmental influences include infection caused by epizootic outbreaks (Bossart et al. 1998) and exchange of morbillivirus between individuals (Duignan et al 1995). However, human influences are more often the cause of death or injury to manatees including the ingestion of debris such as monofilament fishing line (Beck and Barros 1991), oil spills and habitat alteration (Lefebvre and O'Shea 1996). Perhaps the most direct human impact on manatees' survival is collision with watercraft. Mortality rates from 1974 to 1996 indicate that 23.4% of manatee deaths were caused by watercraft (Reynolds 1999). Rehabilitation is part of an official recovery program for only two marine mammals in the United States, the Hawaiian monk seal (*Monachus schauinslandi*) and the West Indian manatee (Wilkinson and Worthy 1999).

Because of the many dangerous and potentially deadly conditions that exist for manatees in the wild, four rehabilitation centers (Homosassa Springs State Park, Lowry Zoological Park, Miami Seaquarium, and Sea World of Florida) have been established in Florida. Other facilities (Walt Disney World's Living Seas at Epcot, Mote Marine

Laboratory, and Bradenton Museum and Planetarium) house manatees mainly for display purposes or act as an intermediate site until they are released. Upon arrival into one of the rehabilitation centers, manatees are placed in a holding tank and assessed by a veterinarian. Once individuals are out of critical care, they often are placed into an exhibit tank for public view. In many cases the manatees are covered with scars or open wounds from boat impacts caused by hulls and propellers. This up close and personal view of injured individuals allows the public to witness some of the impacts that human activities can have on manatees. Educational displays explain how human actions can harm the animals and what steps can be taken to prevent such harm (V. Burke, head keeper at Lowry Zoological Park, personal conversation). More than 14 million people have observed recuperating manatees at Sea World alone between the mid 1970s and 1994. This type of involvement with the public can leave a strong impression on people (Reynolds 1999). The protection and rehabilitation of an endangered species can benefit from not only enhancing public awareness but also from improving our understanding of the species' behavior (Wielebnowski 1998, Domning 1999, Krebs and Davies 1999).

Hartman (1971, 1979) established the framework for what is now known about manatee behavior in the wild by studying patterns of behavior, feeding, and other activities. Reynolds (1981) investigated the feeding behavior of wild manatees in south

Florida. He documented the variety and preference of vegetation on which manatees fed in this region. More recently Zoodsma (1991) examined the behavior of manatees along the Georgia coast and Koelsch (1997) described breeding and feeding behavior of manatees in the Sarasota Bay. Larkin (2000) conducted studies of the reproductive endocrinology of captive female manatees with remarks on the behavior of manatees in captivity. Little behavioral field work has been conducted on the two other species of manatees, the Amazonian and West African manatees. More studies have been done with the dugong, *Dugong dugon*, (Family Dugonidae), which is a relative of the manatee (both families in order Sirenia) and can be seen in small groups in coastal and inland seagrass beds from Mozambique to Vanuatu (Whiting 1999). The dugong appears to be more social than its semi-social manatee cousin, although Koelsch (1997) suggested that manatees might be more social than previously thought.

Relatively little is known about the behavior and sociality of manatees during rehabilitation and extended bouts of captivity. In other species, captivity can alter behavior and prevent the release of individuals back into the wild (Carlstead 1996). The overall objectives for this study were to investigate the influence of captivity on behavior of Florida manatees undergoing rehabilitation, particularly on activity patterns and social interactions. Instead of twenty-four hour activity budgets, observations were conducted around feeding periods because captive animals exhibit the greatest ranges of behaviors during this time. The primary objective for the first part of this study was to determine if the length of time spent in captivity affected behavior of manatees as measured by four behavioral categories: swim, feed, inactive, and miscellaneous. Length of time spent in captivity was expected to influence behavior because the more time an individual remains in captivity, the more likely that activity patterns would change with time. Such changes in activity budgets could result in stereotypies (Boorer 1972), which are considered patterns of movements performed repeatedly that have no apparent function (Odberg 1978) such as continual back and forth movements and searching for food (Carlstead 1996). Alterations in the behavior of manatees that may occur with duration of time spent in captivity could include an increased amount of time spent swimming, an increase in inactivity, as well as a decrease in or extensive occurrence of miscellaneous behaviors (e.g., social interactions, rubbing inanimate objects in the enclosure and investigation of the enclosure).

Facilities that house captive manatees during rehabilitation follow similar guidelines for the care of their animals. However, there are invariably a number of differences that can occur in housing conditions and management protocol. Therefore, the secondary objective for the first part of this study was to determine if the behavior of captive manatees differed among the facilities, by sex, or between summer and winter observation periods. This analysis also was necessary in order to determine if the captive population could be considered a single sample population for other analyses in this study.

Social interactions of captive individuals were examined for the second part of this study. The Florida manatee is considered an asocial or semi-social animal that is usually only seen with other manatees in the wild during mating or in mother-calf pairs (Reynolds and Odell 1991). However, in some areas manatees will aggregate at warm-water refuges during winter. While densities can be high during resting periods, the degree of social interplay is generally low. However, some play behavior has been observed and juvenile males may cavort with adult females (Hartman 1979). The social interactions of manatees in captivity during rehabilitation when individuals may be placed into high-density environments for extended periods have not been investigated. Conflicts and aggression can become heightened in crowded areas especially when there is competition over a resource such as food, mates or space. The resolution of conflict can occur when individuals leave a particular situation, defend territories, form small closely associated groups, or establish dominance hierarchies built upon agonism or affiliation (Pusey and Packer 1999). In wild manatees, Hartman (1979) observed aggression between males that collided into each other over position to mate with a female in estrous. No aggressive interactions were observed outside of these mating behaviors. Hartman observed no territoriality either, but subadults did yield to adults at areas where manatees rubbed themselves. To my knowledge, studies of social behavior of captive manatees have not been conducted. It is not known if captivity creates a situation that produces conflict, resulting in agonism by manatees or how conflict might be resolved, either through affiliation, hierarchies, bonding or territoriality. Therefore, the objectives for the second part of this study were (1) to determine if manatees interacted, (2) manatees will interact more under higher density situations (i.e., more manatees per unit volume of aquarium space), (3) if manatees are more social than previously thought, most interactions will be affiliative in nature, and (4) most interactions will occur just before feeding or when food is becoming depleted. If manatees are truly asocial then, close social bonding should be unlikely to occur. The presence of these social patterns would indicate a greater ability for manatees to behave socially than generally thought. Hence, close confinement in captivity may not be detrimental to their general well-being and rehabilitation. Observing social interactions within groups of captive animals is important because it allows animal caretakers the ability to establish a baseline for normal behaviors exhibited by the animals (Koontz and

Rousch 1996). Regular monitoring of social behavior in captive animals can help caretakers more easily detect and prevent potential problems. Understanding social interactions in captive animals can also aid in monitoring the health of individuals because individuals showing signs of distress may behave differently or abnormally. All of these factors are essential components in the rehabilitation of wild animals and in the long-term care of permanently captive animals that serve as educational ambassadors for their wild counterparts.

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# Chapter II

## Behavior of Captive Florida Manatees during Feeding

### Introduction

In the wild, many herbivores spend a large proportion of their active period foraging (Fernandes 1996). For example, large mammalian herbivores such as African buffalo, *Syncerus caffer*, Burchell's zebras, *Equus burchellii* (Beekman and Prins 1989), African elephants, *Loxodonta africana,* Asian elephants, *Elephas maximus* (Sukumar 1991), and Florida manatees, *Trichechus manatus* (Hartman 1979) may forage 8-12 hours daily. Daily inactive periods of resting and sleeping may comprise 2-10 hours for these mammal species. Remaining periods of time are spent in social encounters and other miscellaneous behaviors. Such herbivores also spend a substantial period of time moving from one location to another to find food, water, or resting spots. Foraging, resting, movement and social interactions can be quantified through activity budgets.

Activity budgets are descriptions of changes that occur in animals to stimuli in their environment (Beltran and Delibes 1994). Twenty-four hour activity budgets have been constructed to describe complete behavioral patterns in animals such as the ocelot, *Leopardus pardalis* (Weller and Bennett 2001). Often however, subsets of 24-hour activity budgets are constructed to examine changes in behavioral patterns such as during mating seasons or foraging bouts (Cote et al. 1997, Maher 1997). Activity budgets constructed around foraging times of animals in captivity can offer insights into their behavior such as the existence of food preferences, amount of time spent foraging, exhibition of abnormal behaviors, or the occurrence of behavior that may cause harm to one's self or another individual. Several factors may alter the activity budgets of animals in captivity ranging from sexual to seasonal differences. A difference in the influence of sexes was found in a study of captive cynomolgus monkeys, *Macaca fascicularis* (Nakamichi et al. 1990) where males moved more actively than females and also contacted other individuals more often than expected, suggesting some type of abnormal behavior. Examining differences in the activity patterns of captive and wild animals may facilitate care and management of animals in captivity. For animals that are undergoing rehabilitation, understanding the potential influence of captivity on activity patterns may assist in the success of rehabilitation efforts.

Some species of animals are brought into captivity for rehabilitation purposes after they have sustained injuries or become ill in the wild. The Florida manatee, *Trichechus manatus latirostris* is a subspecies of the West Indian manatee and is one of the most endangered marine mammals in United States waters, with an estimated total population between 2500-3200 animals (Garrott et al. 1994, Marmontel et al. 1997, Lefebvre 2001). Most manatees in captivity are undergoing rehabilitation because of injuries sustained from impacts with boats (Ackerman et al. 1995) or illnesses such as exposure to red-tide toxins (Bossart 1998). The goal is to release these individuals back to the wild. By observing captive manatees, activity budgets can be constructed to help provide the best possible temporary environment, as well as aid in the release process of rehabilitated individuals. The activity budget of wild Florida manatees consists of 8-12 hours foraging (Hartman 1971, 1979, Reynolds 1981) and 8-10 hours resting and sleeping (Hartman 1979), with the remaining time occupied by social encounters, movement from one location to another, and miscellaneous behaviors such as mating and rubbing at particular areas (Zoodsma 1991, Koelsch 1997). Yet, little behavioral research has been conducted on the behavior of captive individuals.

Captive Florida manatees can be found in seven facilities throughout Florida, two in Ohio, and one in California. Individual manatees may be held in captivity for months to years to decades depending on why they are in captivity. My primary objective was to determine if the length of time spent in captivity had an influence on the behavior of captive Florida manatees. The more time an individual remains in captivity, the more likely behavioral patterns will be altered (Boorer 1972). Alterations in the behavior of manatees that may occur with duration of time spent in captivity could include an increased amount of time spent swimming, an increase in inactivity, as well as a decrease in or extensive occurrence of miscellaneous behaviors (e.g., social interactions, rubbing inanimate objects in the enclosure and investigation of the enclosure). The occurrence of these patterns could reduce the success of adjustment back to the wild. In order to determine if length of time spent in captivity had an influence on behavior, other assumptions had to be tested before captive animals could be used as a single population. Therefore, the secondary questions of this study were to determine if behavior differed among facilities, by sex, or between summer and winter observation periods. The influence of different captive environments on manatee behavior is unknown. Some facilities house only a single-sex while other facilities house both sexes with adults being maintained in separate single sex aquariums. In the wild, manatees migrate seasonally in salt and fresh water as temperatures change. In captivity, water temperatures are relatively constant, and all facilities except Disney World's Living Seas at Epcot maintain manatees in fresh water. The captive setting attempts to simulate the wild, yet there are many potential differences that might influence the behavior of manatees undergoing rehabilitation or living permanently in captivity.

## Study Sites and Methods

*Study Sites.* – This research was conducted May-September 2000 and January-March 2001 at zoos and aquariums housing captive manatees, namely Lowry Park Zoo (Tampa, Florida), Mote Marine Laboratory (Sarasota, Florida), Miami Seaquarium (Miami, Florida), Walt Disney World's Living Seas at Epcot Center (Orlando, Florida), Sea World (Orlando, Florida), and Homosassa Springs State Park (HSSP) (Homosassa, Florida) (Tables 1a and b). Parker Aquarium (Bradenton, Florida) was used for testing procedures and not for data collection. Manatees were housed in human-made enclosures approximately 3 m in depth and oval in shape. The exception was HSSP, which is a naturally occurring spring that covers approximately 0.2 ha and reaches depths of 13.5 m. I observed manatees (n=31 for summer, n=27 for winter) at all facilities from an underwater observation area or from above the enclosure.

*Behavioral Observations.* – I conducted instantaneous scans (Martin and Bateson 1986) of the behaviors exhibited by individual manatees. These were recorded once a minute for 180 minutes using an ethogram (Table 2) that I constructed based on observations made at Parker Aquarium in Bradenton, Florida and information from the literature. To create activity budgets, these individual behaviors were categorized into four major classes of behavior: swim, feed, inactive and miscellaneous. The swim category consisted of only a swim behavior. The feed category included bottom feed (e.g., for supplemental food or regular feeding), surface feed, and prepare-to-grasp behaviors. The inactive category included breathe, float, rest, and sleep behaviors, and the miscellaneous category included nibble, nuzzle, push, roll, rub, and upside down behaviors (see Table 2 for definitions).

Manatees at all facilities were fed 25-100 heads of romaine lettuce depending on the number of manatees in the aquarium (one head weighs about 488 grams) (V. Burke, head keeper at Lowry Zoological Park, personal comm.). Epcot would feed 25 heads to their 2 manatees, whereas Homosassa would feed 100 heads to their 9 manatees. Feeding occurred three to four times a day at regular intervals. Individual facilities consistently provisioned the same amount of food to the manatees. Feeding periods, as defined by the amount of food present, lasted approximately 1 hour. Observations were conducted over three consecutive days at a facility around the same feeding interval. The length of time for observations was chosen because there were many constraints at the facilities that prevented longer observational periods including hours of operation, dealing with the public (e.g., observations can be difficult when the public approaches the glass and blocks the full range of view), and logistical issues (e.g., traveling between Georgia and Florida on regular intervals and costs associated with travel). During the winter 2001 season, my observations at Sea World were recorded in one day over the length of three feeding periods and my observations at Epcot were recorded over two days because of time constraints.

Three observational periods were established around feeding intervals: pre-feeding observational period, during-feeding observational period and post-feeding observational period. The time from which observations began until food was introduced to the manatees was defined as the pre-feeding observational period, which lasted from 42-71 minutes during summer 2000 and 60 minutes during winter 2001. The during feeding observational period occurred when food was being consumed (lasting 34-87 minutes) and the post-feeding observational period was defined to begin when 90% of the original amount of food had been consumed (lasting 35-85 minutes). I counted the number of heads of romaine lettuce that remained unconsumed in the enclosure every five minutes. The total number of minutes for each observational period varied between facilities because of the inability to control exact feeding times. Supplemental food such as carrots and apples were sometimes introduced to manatees by the aquarium or zoo staff in the pre and post feeding periods, which contributed to some of the feeding behaviors recorded.

*Data Analysis.* –Data from each facility were recorded for each manatee for each minute (180 total minutes per day). The mean of all three days was taken for each minute to get a proportion of behaviors exhibited. All animals at the separate facilities then had a value for each behavior for each minute. These raw means were used for analysis. I used Microsoft Excel software computer program.

Because there was little variability among facilities for the during observational period (i.e., manatees spent most of this time feeding), the effect of separate facilities on manatee activity patterns was analyzed using one-way analysis of variance (ANOVA) after combining the pre and post-observational periods into a single observational period. Two and three-way ANOVAs were not used because of an unbalanced design. The dependent variables included the four major behavioral categories (swim, feed, inactive, or miscellaneous), which were analyzed individually. The effect of sex was analyzed in the same manner to determine if activity patterns differed between males and females. Pair-wise multiple comparisons with Tukey-Kramer HSD were used to compare facilities for each behavioral category.

In order to determine if there was a season effect on the behavior of captive manatees, I used paired t-tests. I compared summer 2000 and winter 2001 values between each manatee to determine significant differences. I only used individuals that were present during both seasons for analysis (n=22). I analyzed the four behavioral categories (swim, feed, inactive, and miscellaneous) individually within the combined pre and post observational period (i.e., largely non-feeding periods).

The effect of the duration an animal spent in captivity was analyzed using linear regression. The independent factor was time spent in captivity. Separate regressions were conducted for the four main behavioral categories (swim, feed, inactive, or miscellaneous) for the combined pre and post observational period. A multiple regression was used to determine if there was a significant influence with age in years of manatees and length of time spent in captivity by manatees. All statistics were run using the computer software program JMP, version 3.0.2.

**Results**

The slight difference in the proportion of scans spent feeding had little impact on overall behavioral patterns. The activity patterns of captive manatees were similar in the pre and post-observational periods at all of the facilities. Manatees in captivity swam for an average of 38.6% in the pre and 36.9% in the post-observational period out of the total time they were observed. Captive manatees were inactive 55.1% of the total time observed in the pre-observational period and 54.6% in the post-observational period. Miscellaneous behaviors accounted for 4.5% of activities in the pre and 2.9% in the post.

Captive Manatee Population Comparisons

Before determining the influence of time in captivity on behavioral patterns, the study population was examined for any biologically important differences in behavior that could be attributed to facilities, sex, or seasons.

*Facilities.* -

The effect of facilities on manatee behavior was examined with 31 individuals at six facilities during the summer of 2000. There was no significant facility effect with the combined observational period for swim or inactive. Manatees spent similar amounts of time swimming ($F_{5,25}$=0.16, P=0.97) and remaining inactive ($F_{5,25}$=0.56, P=0.73) among all six facilities. However, there was a significant facility effect with feed ($F_{5,25}$=3.04, P=0.03) and miscellaneous behaviors ($F_{5,25}$=3.05, P=0.03) (Figure 1a). Because of the significant facility effect, pair-wise multiple comparisons were used to compare differences in time spent feeding and performing miscellaneous behaviors among facilities for the observational period. No differences in pair-wise comparisons of facilities were evident with the feed and miscellaneous behavioral categories (Tukey-Kramer *aposteriori* P>0.05).

During winter 2001 season, 27 manatees and five facilities were studied to determine the effect of facility on the behavior of captive manatees. There was no significant facility effect by the observational period for swim, feed, inactive, or miscellaneous behaviors. The proportion of scans that manatees spent swimming ($F_{4,22}$=0.56, P=0.69), inactive ($F_{4,22}$=0.41, P=0.80), and engaged in miscellaneous behaviors ($F_{4,22}$=0.41, P=0.80) did not differ among the facilities. Manatees at the five facilities did differ in the proportion of scans spent feeding for the observational period ($F_{4,22}$=4.09, P=0.01, Figure 1b). However, no significant differences were found with the feed behavioral category using pair-wise multiple comparisons (Tukey Kramer *aposteriori* P>0.05). The proportion of scans spent feeding ranged from 0% (pre), 71-96% (during), and 0-2% (post) for the five facilities. Swim and inactive behaviors had lower occurrences in the during observational period than in the pre and post observational periods; whereas, feeding and miscellaneous behaviors occurred the most in the during observational period.

*Sexes.* –

No significant differences were found between sexes in the combined pre and post observational period for any of the four major behavioral categories for summer and winter, except feed in the summer (Figure 2). The proportion of scans for the summer during which manatees were observed swimming ($F_{1,29}$=0.01, P=0.91), remaining inactive ($F_{1,29}$=1.46, P=0.24), and engaged in miscellaneous behaviors ($F_{1,29}$=0.07, P=0.80) did not differ by sex. However, feed did differ significantly ($F_{1,29}$=16.98, P=0.0003). The proportion of scans for the winter during which manatees were observed swimming ($F_{1,25}$=1.21, P=0.28), feeding ($F_{1,25}$=0.48, P=0.49), remaining inactive ($F_{1,25}$=1.47, P=0.24), and engaged in miscellaneous behaviors ($F_{1,25}$=0.07, P=0.79) also did not differ by sex (Figure 2).

*Seasons.-*

The effect of seasons on manatee behavior was examined with 22 individuals (using the same manatees that were observed for summer and winter in data analysis) at five facilities (Figure 3). The proportion of scans during which manatees were observed in the combined pre and post-observational period did not differ among seasons for the four behavioral categories (Table 3). Swim and inactive were the most predominate behaviors occurring for 40% of the scans; miscellaneous behaviors, especially the rub behavior, were observed for approximately 18% of the scans while feeding was infrequent (<2%) in the pre and post combined observational periods (Appendices A-F).

<u>Length of Time Spent in Captivity</u>. –

Thirty-one manatees in summer 2000 and twenty-seven manatees in winter 2001 were used to analyze effects of time spent in captivity, which ranged from 0.25-45 years. The duration of time in captivity was not a good predictor of manatee activity. In the summer 2000 season, the proportion of scans for which manatees were observed swimming, feeding, remaining inactive, and miscellaneous behaviors did not show a significant linear relationship with the length of time that manatees spent in captivity for that combined pre and post-observational period (Table 4a, Figures 4a-d, all $P>0.12$, $R^2<0.08$). The proportion of scans observed for the winter 2001 season also did not show a significant linear relationship with time in captivity for swimming, feeding, remaining inactive, and miscellaneous behaviors for the combined pre and post-observational period (Table 4b, Figures 5a-d, all $P>0.56$, $R^2<0.01$).

I examined whether age in years helped explain any variation in behavior using a multiple regression. For summer 2000 and winter 2001, time in captivity and age were not found to significantly influence swimming, feeding, remaining inactive, or exhibiting miscellaneous behaviors (all $R^2$ between 0.0001 and 0.07).

**Discussion**

The activity patterns of the population of manatees that were studied in captivity did not differ significantly by facility, sex, or season. Hence, the influence of time spent in captivity on activity patterns was examined using the sampled captive population of 27-31 animals held in captivity from three months to 45 years. The proportion of time spent in the four major behavioral categories (swim, feed, inactive, and miscellaneous) showed no linear relationship with time in captivity. Abnormalities in behavior were not observed suggesting there are few behavioral changes from manatees in captivity relatively recently (3 months) versus much longer periods (40 years). Furthermore, only minor differences were found in feeding by manatees at the different facilities.

Manatees at Homosassa Springs State Park and Lowry Zoological Park as well as Sea World and Lowry differed in the proportion of scans spent feeding for the post-observational period in the summer 2000 season. Manatees at Homosassa were fed in a small blocked off area (approximately 3.5m x 6.5m) of the spring (a 0.2 ha area) called the "salad bar" to avoid having food particles float throughout the exhibit. Once the manatees started to forage, they did not leave the salad bar until all the food was consumed. Therefore, little lettuce was present in the post-observational period. At Sea World, a similar scenario occurred. These manatees were fed in an area approximately the size of an adult manatee (3m x 2m). All manatees remained in this area until the food was consumed. Manatees of Epcot fed at the bottom of their tank from feeding tubes constructed out of PVC piping. These manatees remained at the feeding tubes until all food had been consumed. Once again, there was little food debris remaining in the tank during the post-observational period. At Lowry Zoological Park, Mote Marine Laboratory, and Miami Seaquarium, the animal caretakers dispersed the lettuce throughout the aquarium. The animals then foraged throughout the entire aquarium producing many shreds of lettuce. After the heads of lettuce were consumed, the manatees foraged on the remaining shreds (<10% of the remaining food). This increased their foraging time in the post-observational period (defined as starting when 90% of the food had been consumed). Therefore, Lowry and Mote had a higher percentage of manatees exhibiting foraging behaviors (21% at Lowry and 20% at Mote) in the post-observational period than manatees at Epcot (13%), Seaquarium (2%), Homosassa (1%) and Sea World (0%).

Providing food throughout varying times of the day may represent conditions that are similar to those for manatees in the wild during warmer seasons and waters. Wild manatees during these times of the year are not faced with thermal barriers restricting foraging activities (Reynolds and Odell 1991). Koelsch (1997) made 1265 observations of wild manatees in the Sarasota Bay, Florida. Of those observations, 251 (20%) involved feeding. Therefore, facilities that want their manatees to forage for longer periods of time could provide smaller proportions of food more often throughout the day or disperse the food.

Providing fewer and longer feeding periods may represent a pattern of feeding that more closely resembles foraging behavior seen with manatees in northern and gulf waters of Florida during cooler seasons of the year. Wild manatees living in these areas are restricted to warmer springs. They can only feed in short bursts out of the springs into cooler waters because continued exposure to cold temperatures can kill manatees (Lefebvre and O'Shea 1996). Hence, giving more food in a restricted area in captivity may simulate winter feeding behavior in more northern wild manatee populations.

In the summer 2000 season, only manatees at Seaquarium and Lowry showed significant differences in the proportion of scans spent in exhibiting miscellaneous behaviors for the pre and during observational periods. These differences were based on fairly rare behaviors and as such, were not considered biologically significant. However, further studies investigating these miscellaneous behaviors, particularly social interactions, could improve our understanding of manatee behavior in captivity (see chapter III).

Behavioral studies examining activity budgets of animals placed into captivity can aid in the management of species at zoos and aquariums because they allow animal caretakers to be aware of changes in animals such as stress or alterations in amount of food consumed (Kleiman 1994, Weller and Bennett 2001). Examining activity budgets around the feeding time of captive animals can also reveal a wide array of behaviors that resemble those exhibited by animals in the wild. Examples of animals in captivity for which activity budgets have been constructed based on foraging activities include: chimpanzees, *Pan troglodytes* (Baker and Phillip 1996), Argentine hognosed snake, *Lystrophis dorbignyi* (Francini et al. 1995), American bison, *Bison bison* (Robitaille and Prescott 1993), and Oriental small clawed otters, *Anonyx cinerea* (Pellis 1991). These studies were conducted to compare feeding behavior of captive and wild animals. Some feeding abnormalities were seen in chimps such as regurgitation and reingestion. No such abnormalities were observed by manatees in this study.

Effects that captivity may have on animals include stereotypies (Boorer 1972), which are considered patterns of movement performed repeatedly that have no apparent function (Odberg 1978). Often stereotypies occur before feeding time and animals will exhibit behaviors that simulate foraging and hunting including continual back and forth movements and searching for food. These are considered clear indications of abnormal animal-environment interactions. Activity rates are higher prior to feeding versus after feeding in such cases. Stereotypies may have a number of causes including inability to reach a desired place, inability to avoid a source of disturbance, space limitations and length of time spent in captivity (Carlstead 1996). However, no evidence of heightened activity prior to feeding was noted in this study with captive manatees. The similar ratio in which behaviors occurred for the pre and post-observational periods indicated little anticipation of a feeding period or associated stress prior to feeding compared to post feeding.

Changes that might occur in the first few weeks to months of captivity could not be assessed in this study. All animals had been in captivity at least three months. Animals that are in the wild have adapted to their surrounding environment through generations of natural selection. Behavior has adapted specifically to certain habitats to exploit food resources based on seasonal, social and biological factors influencing them. However, once animals are placed into captivity, the environment greatly changes from the natural condition. Thus, the ability for the individual to adjust to changes in a captive situation greatly influences how it will handle its new environment (Carlstead 1996). Because no differences were found with the length of time spent in captivity by manatees, management implications based on this information may aid in the release of captive manatees back into the wild. If their behavior remains relatively unaffected by captivity, then length of time spent in captivity may not be an important factor when determining if an animal is releasable or not. Maintaining manatees with other individuals with which they are familiar or introducing new manatees into an enclosure cannot explain factors that may affect time spent in captivity. Some facilities have captive born individuals (Mote) while others have had a similar composition of manatees for several years (Homosassa and Epcot).

This study did not examine the influence of human interactions (i.e. the presence of zoo caretakers cleaning, feeding, etc.) on the behavior of captive manatees. The acclimation of manatees to humans and their machines could be problematic in the wild. Injuries from boats and ingestion of human debris are major sources of mortality for wild manatees (Beck and Barros 1991). If rehabilitated manatees are accustomed to humans, then their survival may be impaired. Alternatively, wild manatees that are injured by watercraft already may be too acclimated to humans, and captivity may do little to alter their disposition. Further studies are needed to determine if the interaction of humans and manatees in captivity alters the behavior of manatees towards humans once released back into the wild.

**Tables and Figures**

Table 1a: Research sites used for behavioral observations of captive Florida manatees from May through September 2000

| Facility | Number of Manatees | Sex | Range of Age (Years) | Range of Time in Captivity (Years) |
|---|---|---|---|---|
| Lowry Zoological Park | 6 | 4 Females 2 Males | 3-15 | 0.25-15 |
| Mote Marine Laboratory[1] | 2 | 2 Males | 11-14 | 11-14 |
| Miami Seaquarium | 5 | 5 Females | 1-55 | 0.6-43 |
| Disney World's Living Seas at Epcot | 2 | 2 Females | 6-10 | 4-6 |
| Sea World of Florida | 7 | 5 Females 2 Males | 1-23 | 1-18 |
| Homosassa Springs State Park | 9 | 9 Females | 6-38 | 4-32 |
| Parker Aquarium[2] | 2 | 2 Males | 3-53 | 1-53 |

[1]Mote was not used during the winter (Table 1b) because of observational difficulties.

[2]Manatees were used to establish an ethogram but not used in data collection.

Table 1b: Research sites used for behavioral observations of captive Florida manatees from January through March 2001

| Facility | Number of Manatees | Sex | Range of Age (Years) | Range of Time in Captivity (Years) |
|---|---|---|---|---|
| Lowry Zoological Park[3] | 3 | 2 Females 1 Male | 0.75-6.5 | 0.6-4.5 |
| Miami Seaquarium[4] | 7 | 7 Females | 1.5-55.5 | 0.75-43.5 |
| Disney World's Living Seas at Epcot | 2 | 2 Females | 6.5-10.5 | 4.5-6.5 |
| Sea World of Florida[5] | 7 | 4 Females 2 Males | 1.5-23.5 | 1.5-18.5 |
| Homosassa Springs State Park | 9 | 9 Females | 6.5-38.5 | 4.5-32.5 |

Differences between summer and winter sample sizes exist because:

[3] Two females were released back into the wild and one male was unable to be observed because of construction around his enclosure.

[4] Two females were added to the enclosure for rehabilitation because of cold stress.

[5] One female was released back into the wild.

Table 2: Ethogram of behaviors exhibited by captive manatees at seven facilities throughout Florida from May 2000 to March 2001.

| Behavior | Description |
|---|---|
| **Swim** | |
| Swim | Moving through the water at a steady pace |
| **Feed** | |
| Bottom Feed | Manatee forages on bottom of the tank |
| Surface Feed | Manatee surfaces and feeds on food, snout is up |
| Prepare to Grasp | Manatee reaches for food with its mouth while the lips flare in preparation to eat food |
| **Inactive** | |
| Breathe | Manatee brings nostrils above the water onto the surface for air and nostrils open |
| Float | Manatee remains still while being suspended in water or near the surface |
| Rest | Manatee orients body in a motionless position on the bottom of the enclosure, but eyes are open |
| Sleep | Manatee orients body in a motionless position at the bottom of the enclosure with head and body down and eyes closed |
| **Miscellaneous** | |
| Nibble | Manatee nibbles on an inanimate object in the tank |
| Nuzzle | Manatee touches another manatee with its mouth |
| Push | Manatee uses flippers to push off the enclosure's sides or bottom in order to propel the body |
| Roll | A complete turn of the body in a clockwise or counter-clockwise motion while swimming |
| Rub | Manatee rubs its body along the surrounding edges within the enclosure |
| Upside Down | Turning body so that it is ventral up and remaining in this position near the surface |

Table 3: The results from comparing summer 2000 and winter 2001 season data using paired t-tests for the combined pre and post observational period (see Figure 3 for mean values).

| **Behavioral Category** | **t** | **df** | **P** |
|---|---|---|---|
| Swim | 0.13 | 21 | 0.90 |
| Feed | 2.03 | 21 | 0.06 |
| Inactive | 0.48 | 21 | 0.08 |
| Miscellaneous | 0.34 | 21 | 0.12 |

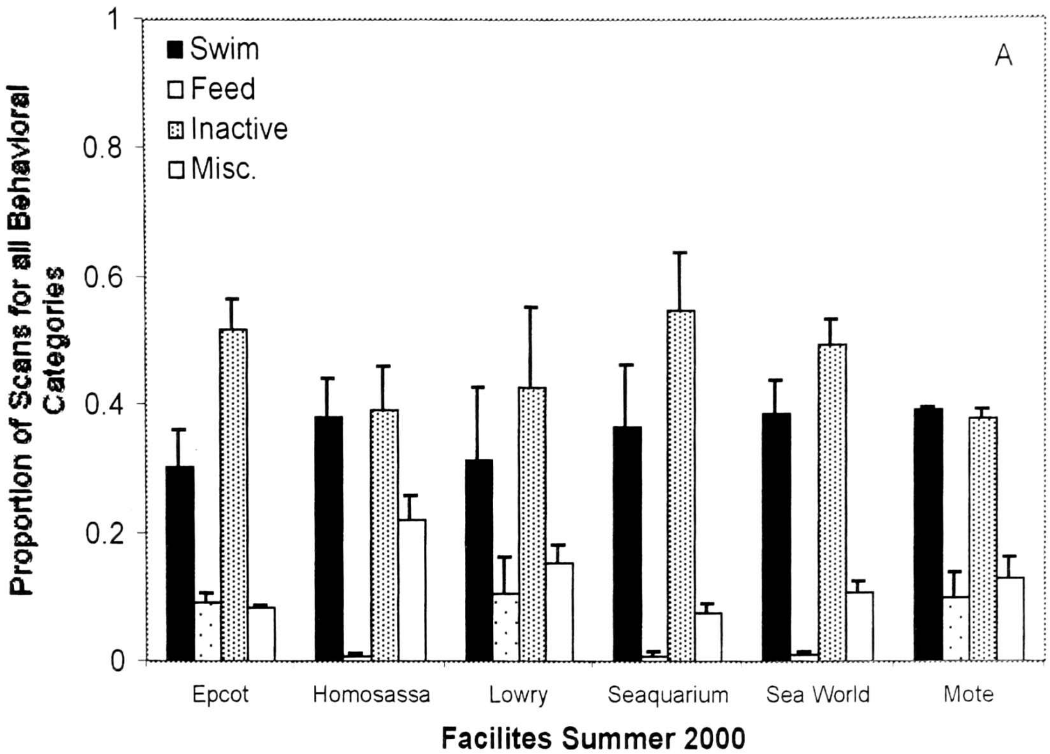
Table 4: Results using multivariate linear regression for length of time spent in captivity during (a) summer 2000 and (b) winter 2001 for the combined pre and post observational period (see Figure 4 for mean values).

(a)

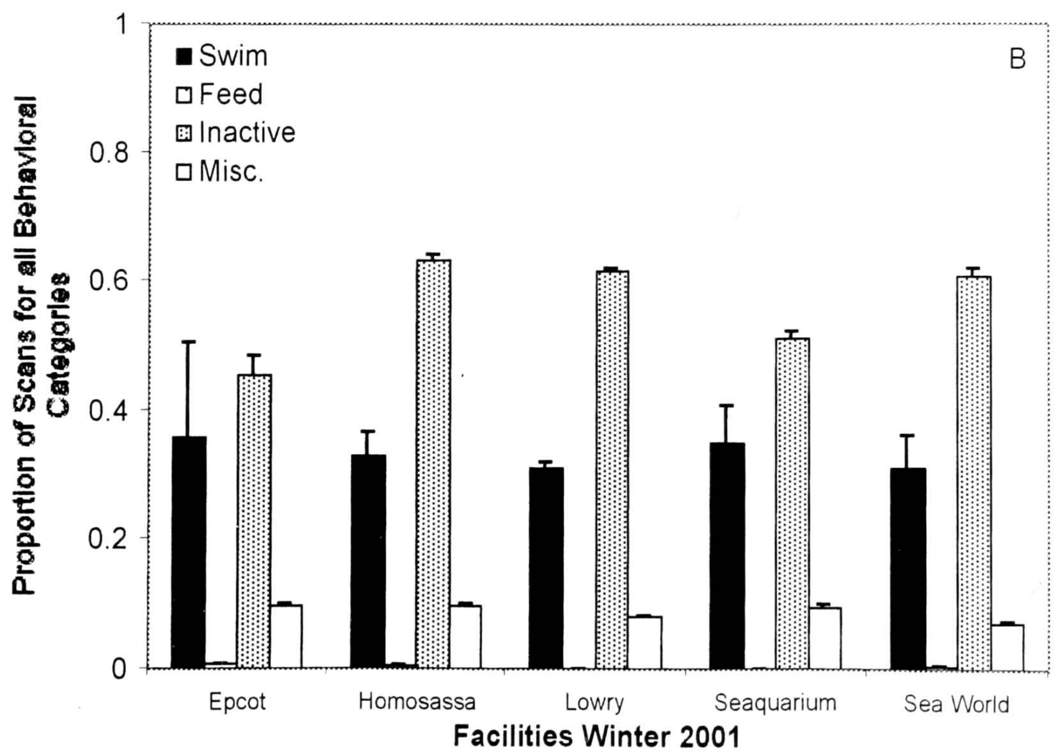
| **Behavioral Category** | $\mathbf{F_{1,29}}$ | **P** | $\mathbf{R^2}$ |
|---|---|---|---|
| Swim | 0.21 | 0.65 | 0.007 |
| Feed | 0.10 | 0.75 | 0.004 |
| Inactive | 1.04 | 0.32 | 0.03 |
| Miscellaneous | 2.56 | 0.12 | 0.08 |

(b)

| **Behavioral Category** | $\mathbf{F_{1,25}}$ | **P** | $\mathbf{R^2}$ |
|---|---|---|---|
| Swim | 0.15 | 0.71 | 0.006 |
| Feed | 0.07 | 0.79 | 0.003 |
| Inactive | 0.18 | 0.68 | 0.007 |
| Miscellaneous | 0.36 | 0.56 | 0.01 |



1
0.8
0.6
0.4
0.2
0
Proportion of Scans for all Behavioral Categories
Swim
Feed
Inactive
Misc.
A
Epcot
Homosassa
Lowry
Seaquarium
Sea World
Mote
Facilites Summer 2000

1
0.8
0.6
0.4
0.2
0
Proportion of Scans for all Behavioral Categories
Swim
Feed
Inactive
Misc.
B
Epcot
Homosassa
Lowry
Seaquarium
Sea World
Facilities Winter 2001

Figures 1a-b: Mean proportion of scans ($\pm$/SE) manatees were observed swimming, feeding, inactive, and exhibiting miscellaneous behaviors at six facilities (a) in summer 2000 and five facilities (b) in winter 2001 with the pre and post-observational period combined.

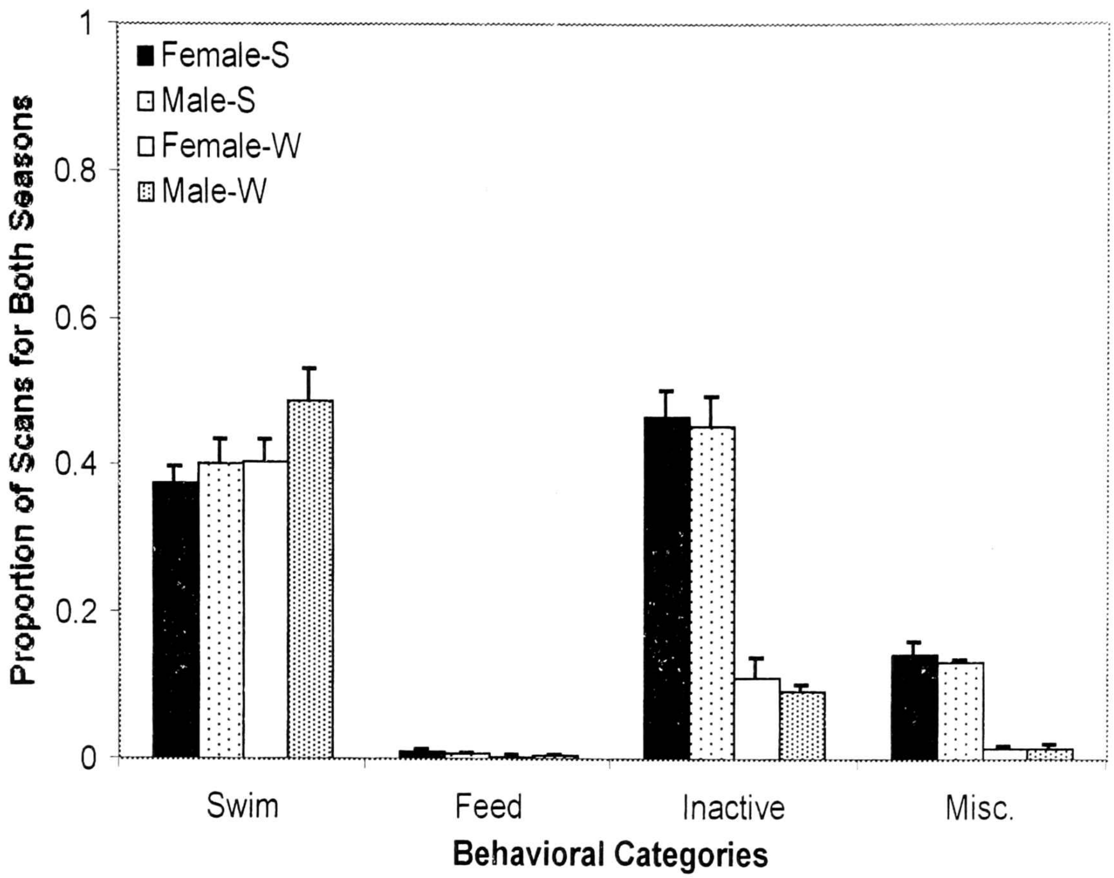



Figure 2: Mean proportion of scans (±/SE) manatees were observed swimming, feeding, inactive, and exhibiting miscellaneous behaviors by male and females in the combined pre and post-observational period for both seasons (S=summer, W=winter).

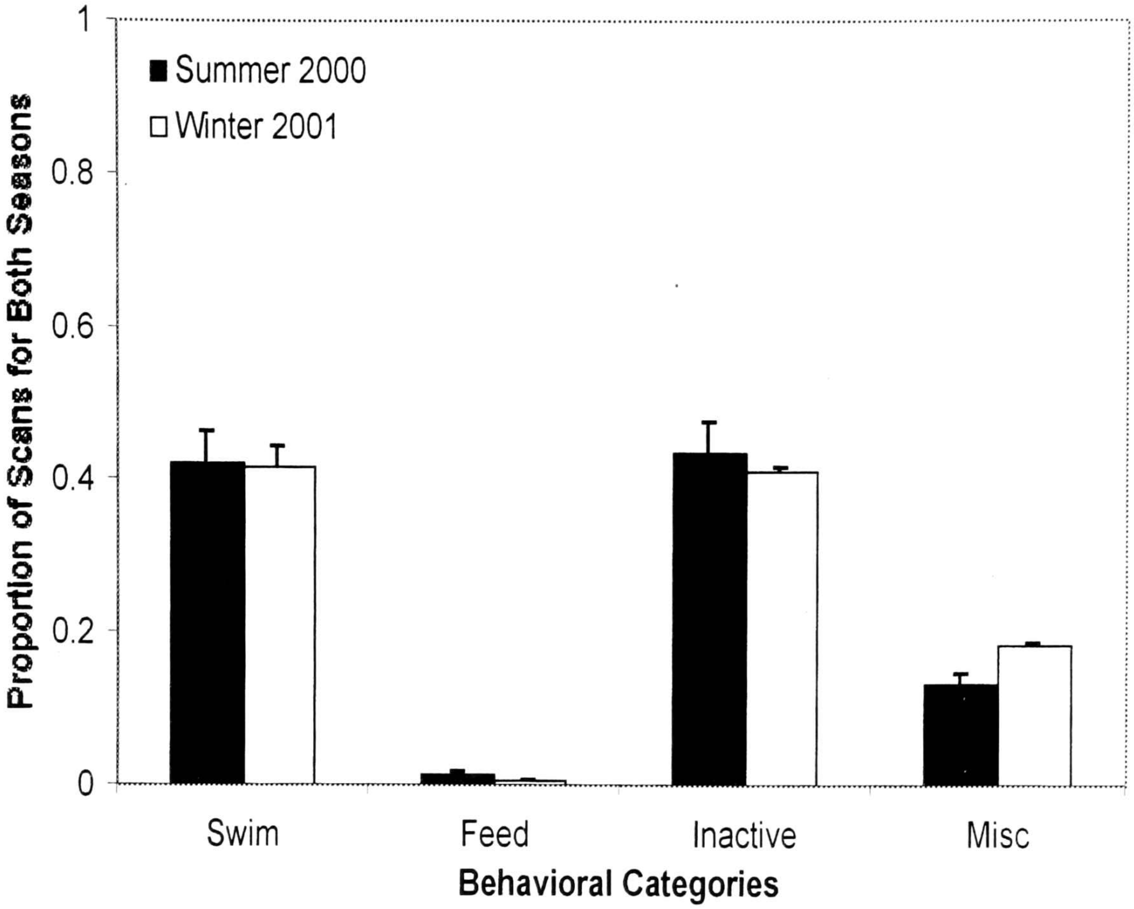
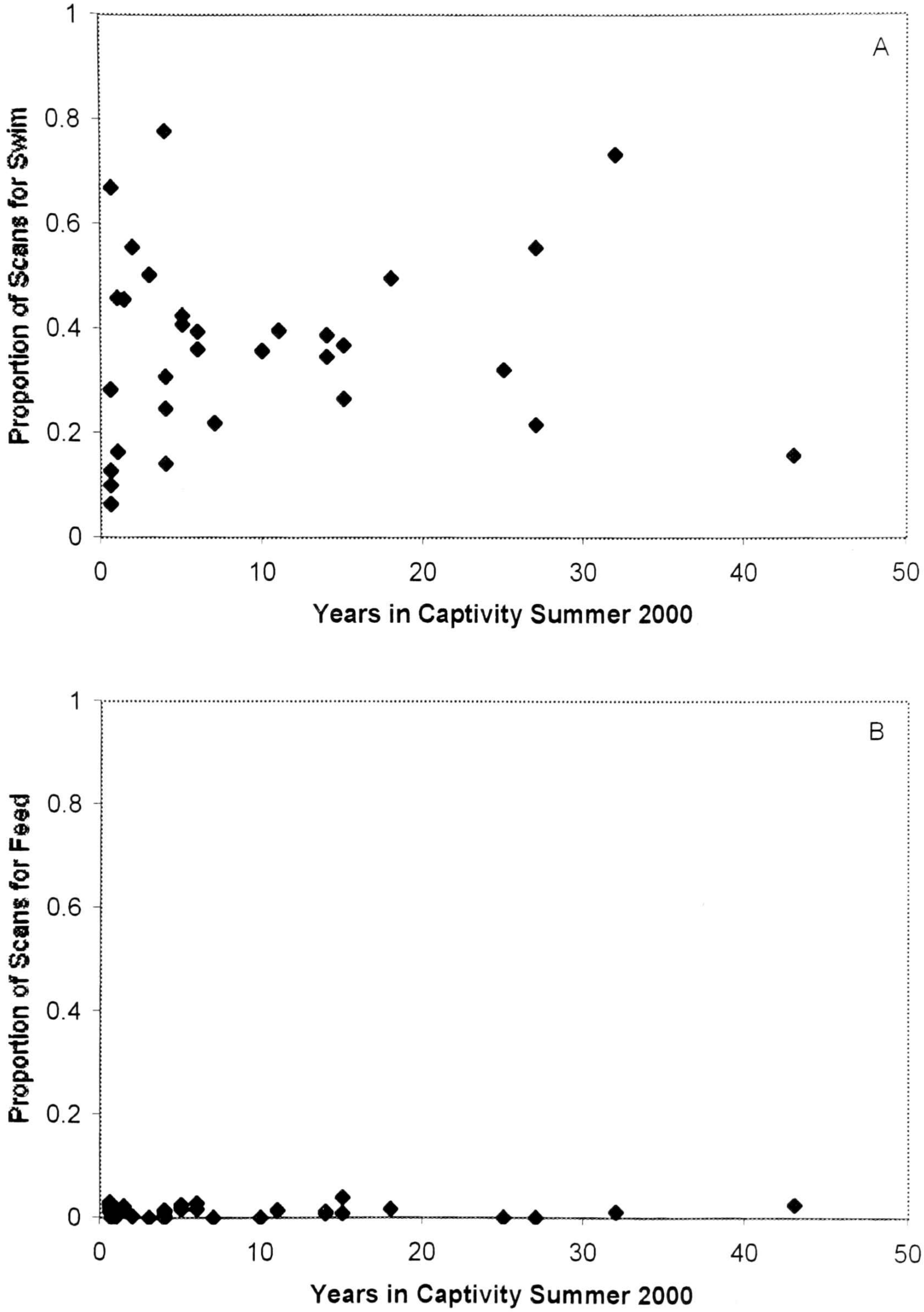
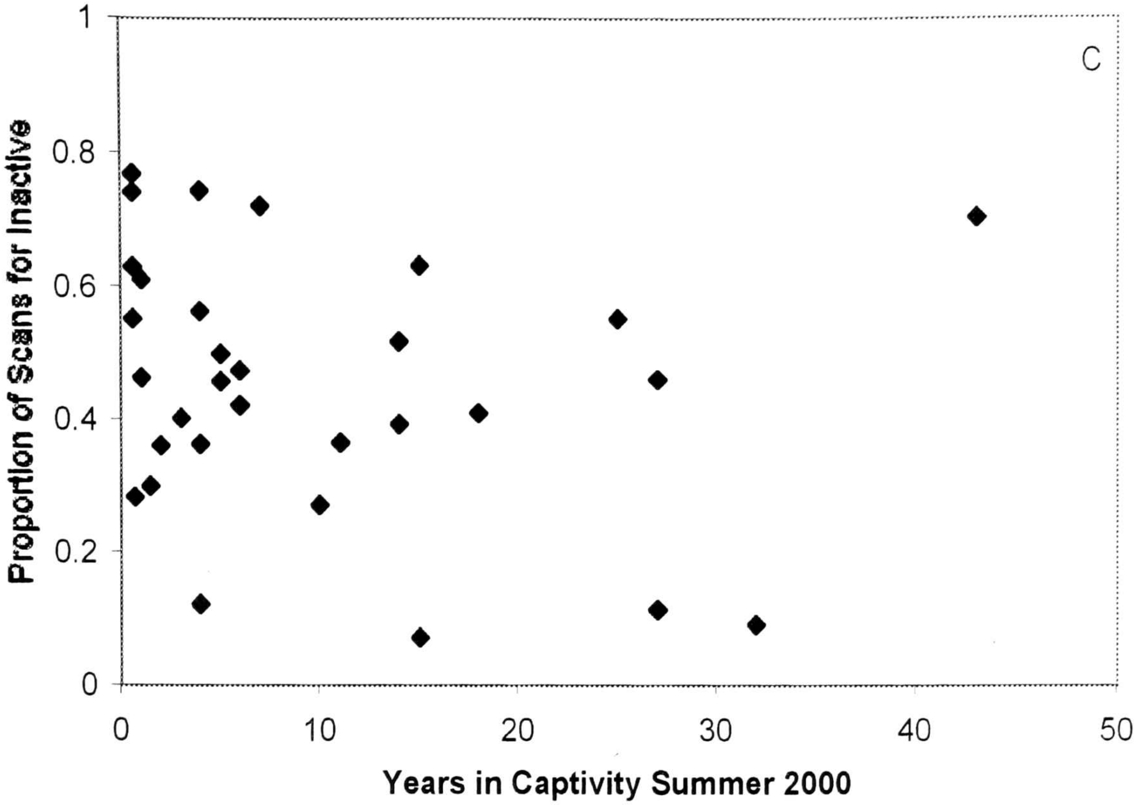
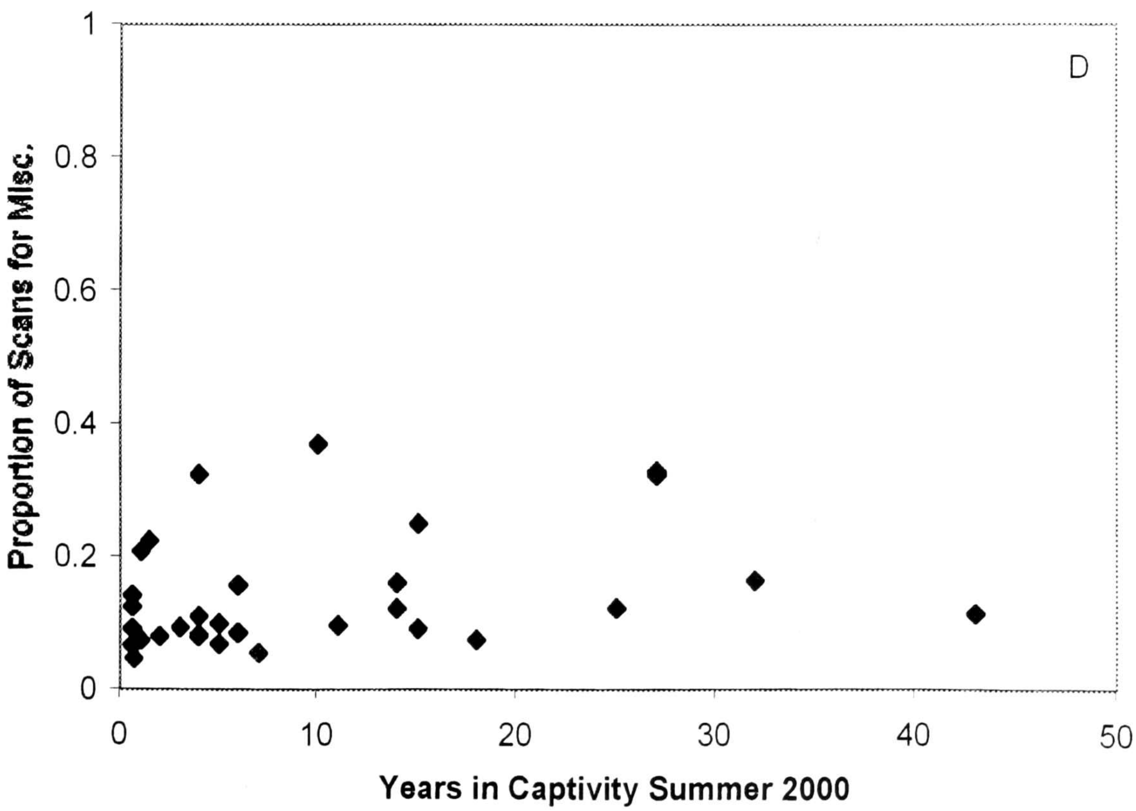


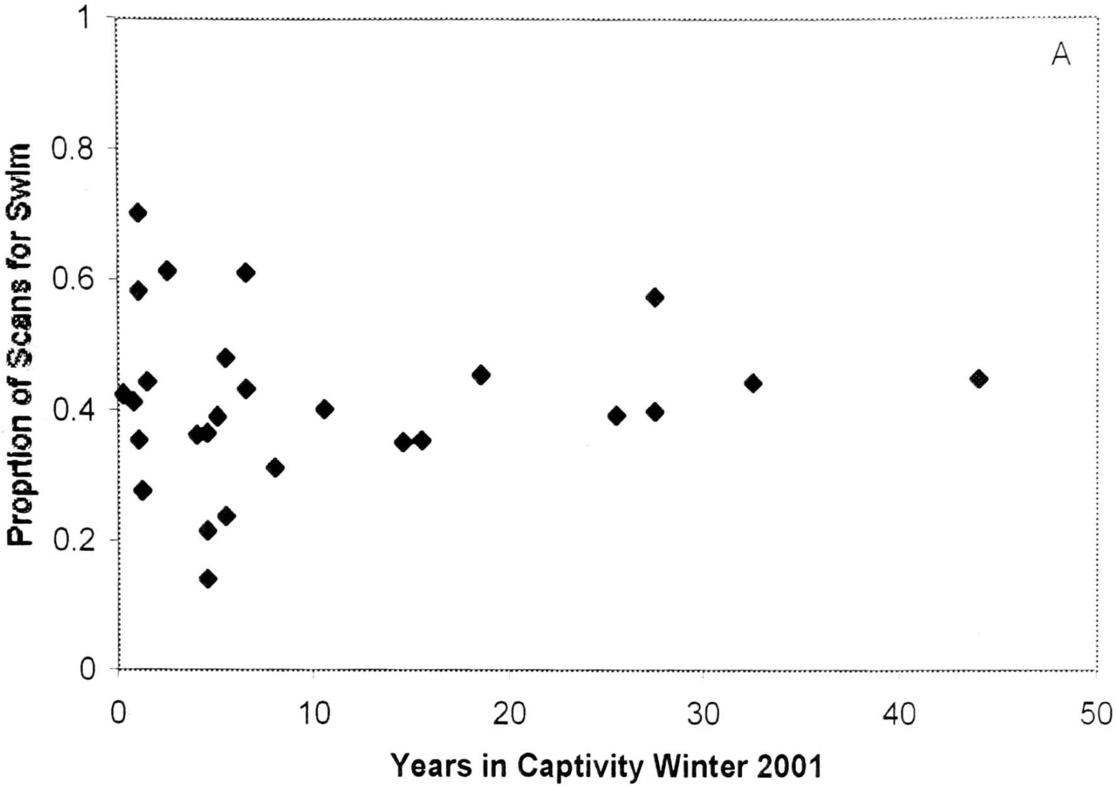

Figure 3: Mean proportion of scans (+/SE) for the four behavioral categories between the two seasons for the combined pre and post-observational period.

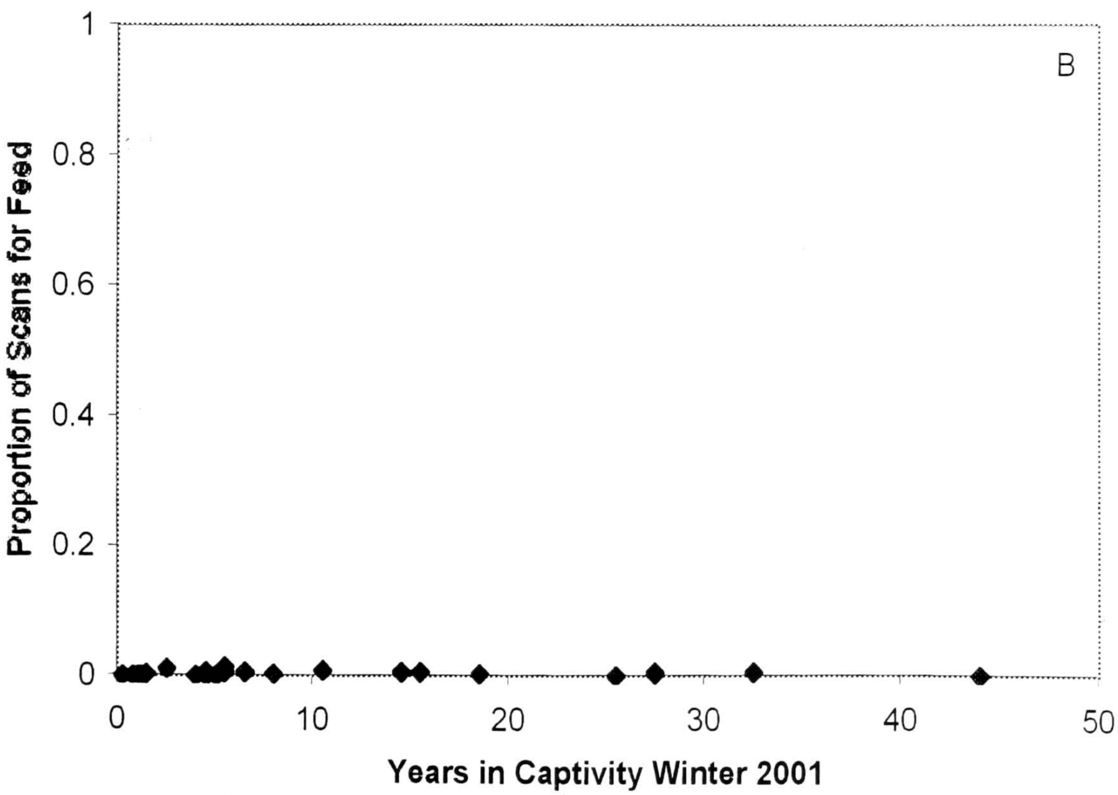

A
Proportion of Scans for Swim
Years in Captivity Summer 2000
B
Proportion of Scans for Feed
Years in Captivity Summer 2000

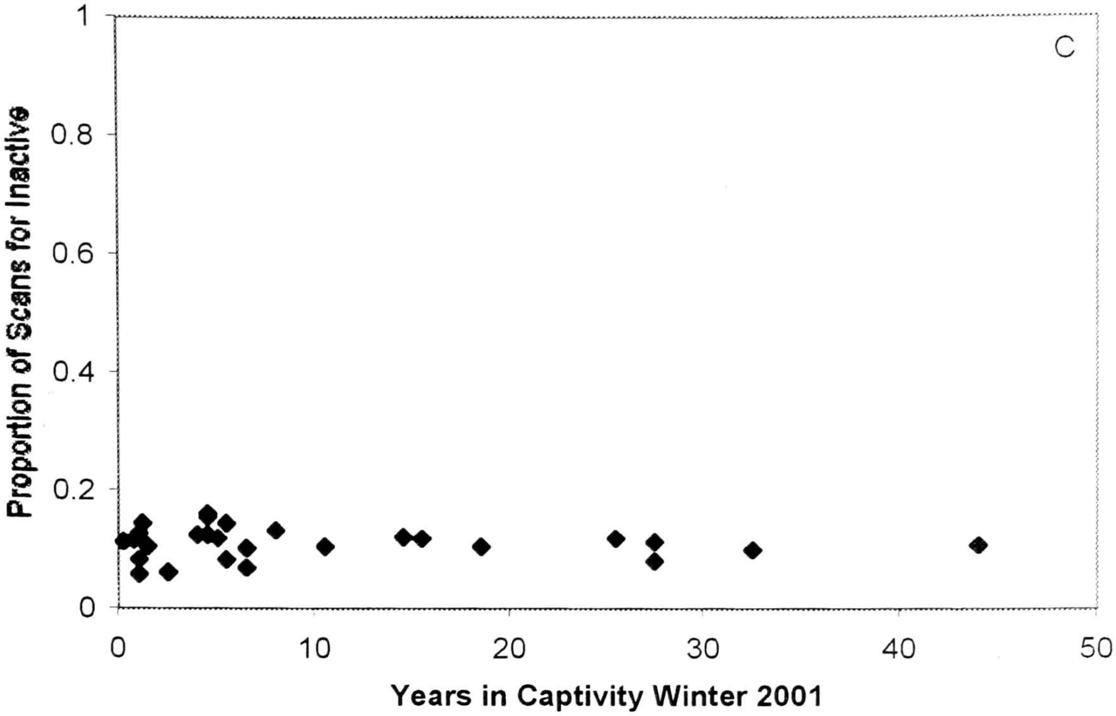

C
Proportion of Scans for Inactive
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
Years in Captivity Summer 2000

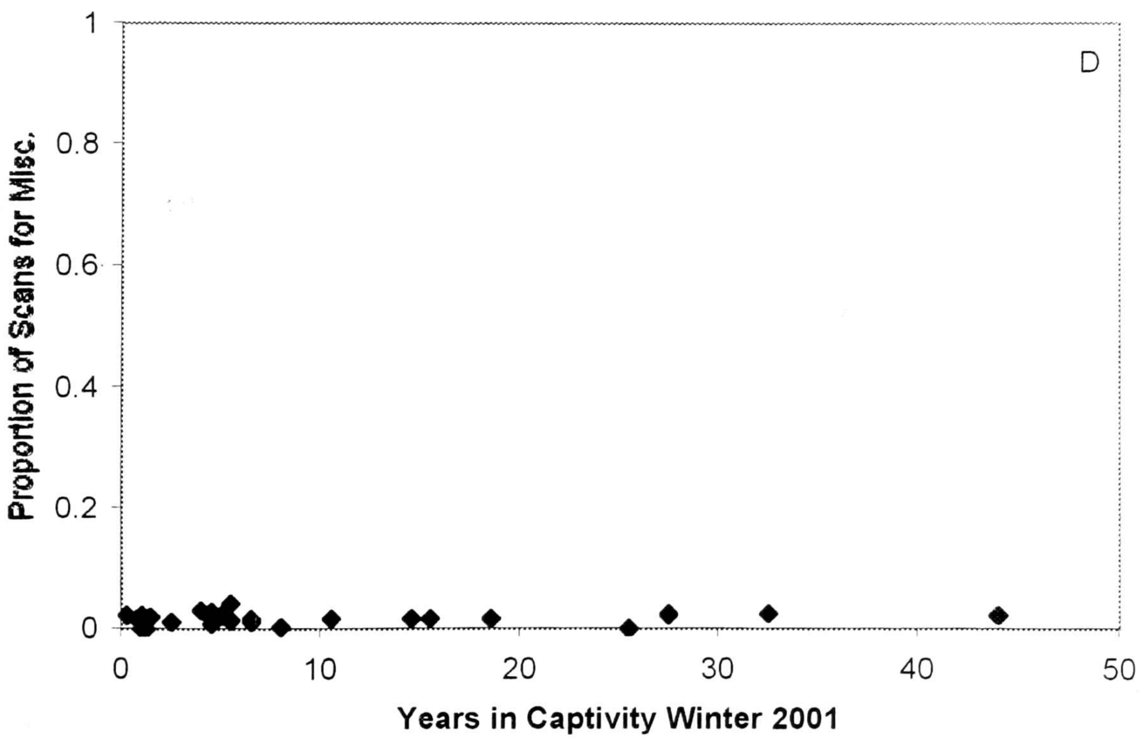

D
Proportion of Scans for Misc.
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
Years in Captivity Summer 2000

Figures 4a-d: Mean proportion of scans for (a) swim, (b) feed, (c) inactive, and (d) miscellaneous behaviors in the combined pre and post-observational period over the length of time spent in captivity by manatees in summer 2000.


A
Proprtion of Scans for Swim
Years in Captivity Winter 2001
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50


B
Proportion of Scans for Feed
Years in Captivity Winter 2001
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50


C
Proportion of Scans for Inactive
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
Years in Captivity Winter 2001


D
Proportion of Scans for Misc.
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
Years in Captivity Winter 2001

Figures 5a-d: Mean proportion of scans for (a) swim, (b) feed, (c) inactive, and (d) miscellaneous behaviors in the combined pre and post-observational period over the length of time spent in captivity by manatees in winter 2001.

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## Chapter III

## Social Interactions in Captive Florida Manatees

### Introduction

Organization of individuals into social groups is likely to evolve when the benefits of group living outweigh the costs. Benefits of group living include greater access to resources and protection. Living in groups has ecological costs including an increase in competition for food, space, and mates and exposure to parasites, pathogens, and predators (Krebs and Davies 1996). Conflicts and aggression can become heightened in crowded areas especially when there is competition over a limited resource. The resolution of conflict can occur when individuals leave a particular situation, defend territories, form small closely associated groups, or establish dominance hierarchies built upon agonism or affiliation (Pusey and Packer 1999).

Florida manatees (*Trichechus manatus latirostris),* a subspecies of the West Indian manatee, are considered semi-social or asocial animals, because they generally do not form organized social structures. Manatees are usually seen traveling in warmer coastal waters alone or in mother-calf pairs, with such bonds lasting until the calf is approximately one year old (Reynolds and Odell 1991). From 1993-1996, Koelsch (1997) observed manatees in Sarasota Bay, Florida and noted some strong pair-bonds among adult manatees. In addition, associations were stronger within than between the sexes, especially for males. These non-random association patterns along with the social facilitation noted by Reynolds (1981) suggest that manatees may be more social than previously thought (Koelsch 1997). Investigating the extent and type of interactions among manatees held in captivity was the main drive of the current study.

Manatees in the wild face many problems in their aquatic environment including ingestion of foreign materials (i.e., fishing line, hooks, plastic and other refuse) (Beck and Barros 1991), exposure to toxins such as red tide (Bossart et al. 1998), and collisions with boats (Wright et al. 1995). Injured or sick manatees are often reported by the public and taken into captivity for rehabilitation. Once these mammals are put into captive facilities, they are sometimes placed with several other manatees of the same sex. However, little is known about how these supposed asocial animals behave in the constant presence of multiple conspecifics. Therefore, the specific objective of this research was to determine if manatees in captivity exhibit behaviors that might reveal signs of conflict or serve to reduce conflict. I observed manatees before, during, and after feeding periods because conflicts might arise in anticipation of or during consumption of food (a potentially limited resource). I examined the hypotheses that (1) manatees will rarely interact, (2) manatees will interact more under higher density situations (i.e., more manatees per unit volume of aquarium space), (3) if manatees are more social than previously thought, most interactions will be affiliative in nature, and (4) most interactions will occur just before feeding or when food is becoming depleted.

**Study Sites and Methods**

*Study Sites.* – This research was conducted from January through March 2001 at zoos and aquariums housing captive manatees including Homosassa Springs State Park (Homosassa, Florida), Lowry Zoological Park (Tampa, Florida), Sea World of Florida (Orlando, Florida), and Walt Disney World's Living Seas of Epcot Center (Orlando, Florida). Manatees were housed in human-made enclosures approximately 3 m in depth and oval in shape. The exception was Homosassa, which is a naturally occurring spring that covers approximately 0.2 ha and reaches depths of 13.5 m. Manatees (n=27) at all facilities were viewed from an underwater observation area or from above the enclosure. Homosassa contains several millions gallons of water (estimated at 3 million with 9 manatees), Lowry Zoological Park contains 125,000 gallons of water (3 manatees), Sea World contains 375,000 gallons of water (6 manatees), and Epcot contains approximately 206,000 gallons of water (2 manatees).

*Behavioral Observations.* – Manatees were watched continuously for 180 minutes over three days around feeding times. During the three hours of continuous observations for all interactions, I recorded all occurrences of contacts between manatees and spatial displacement by manatees (Martin and Bateson 1986). Observations were made at four facilities with twenty individuals for a total of 36 hours. Manatees were observed for this amount of time because there were constraints at the facilities that prevented longer observation periods including operating hours, interference in observations when visitor numbers were high, and logistical issues. No adult males were observed for this study. Agonistic and affiliative interactions between manatees (sender-receiver) and displacement of manatees were recorded. Agonistic interactions were defined as contacts in which the sender's head touched the receiver with some momentum or caused displacement of the receiver. Displacement was considered to occur when one manatee (sender) caused another manatee (receiver) to move from its location because of the presence or movement of the sender. Other aggressive interactions occurred when the sender's tail hit the receiver with force as it swam away. Affiliative interactions included all other contacts (head to different body parts, body to different body parts, fin to different body parts, and tail to different body parts). Incidental contacts occurred when an animal brushed against another animal. These contacts were rare and not recorded.

Manatees at all facilities were fed 25-100 heads of romaine lettuce depending on the number of manatees in the aquarium [(one head weighs approximately 488 grams) (V. Burke, head keeper at Lowry Zoological Park, personal comm.)]. Feeding occurred three to four times a day at regular intervals. Three observational periods were defined as pre-feeding observational period, during-feeding observational period, and post-feeding observational period. The pre-observational period occurred during the first 60 minutes of observations before any food was given to the manatees. The during-observational period occurred when the manatees were feeding and the post-observational period was defined as when 10% or less of the food remained. The number of heads of lettuce that remained in the aquarium were counted and recorded every 5 minutes. Feeding periods lasted approximately one hour. Supplemental foods such as carrots, kale, and apples were sometimes provided to manatees by the aquarium staff.

*Data Analysis.* –The total number of contacts (agonistic or affiliative) for each day and facility were counted. Percentages were calculated to determine how often each type of interactions occurred at each facility by observational period over the three consecutive days of observation. Percentages also were calculated with individual manatees to determine how often each manatee was a sender or a receiver for a contact by the observational periods over all three days. Sender-receiver tables were created for each facility. Affiliative contacts were used instead of agonistic for sender-receiver tables because of the low occurrence of agonistic contacts. Animals were ordered in tables based on the total number of affiliative contacts sent. Chi-square analyses were used (1) to examine if affiliative contacts were more likely before or after feeding at separate facilities and (2) to compare the distribution among facilities of affiliative contacts before and after feeding. I ran a linear regression using Microsoft Excel computer software program to determine the effect of density on total number of contacts. The coefficient of dispersion was also calculated using the number of contacts initiated by each manatee to determine if contacts fit a Poisson distribution.

**Results**

At each of the four facilities, two to nine adult females were observed. Two of the facilities had one (Lowry Zoological Park) and two (Sea World of Florida) juvenile males housed with the females. Of the 228 contacts recorded, only 10 (4.39%) were aggressive. The manatees at Lowry Zoological Park accounted for nine out of the ten aggressive encounters and seven were observed in a single day (Table 1). The sender's head to the receiver's body initiated all aggressive contacts. The number of total contacts per day ranged from 10-34 at the four facilities (means $\pm$SE of contacts per day: Day 1=20.25$\pm$6.33, Day 2=19$\pm$4.45, and Day 3=17.75$\pm$2.66).

No contacts were observed while the manatees were feeding. Of the 218 affiliative encounters, 98 (44.95%) occurred in the pre feeding period and 120 (55.05%) in the post-feeding period. The pre-feeding period was always 60 minutes long while the post period ranged from 33 to 73 minutes (55.67±3.62 minutes). No differences were found in the number of affiliative contacts in the pre versus the post observational period within each facility (all $X^2<3.84$, df=1, P>0.05) or with the distribution of affiliative contacts in the pre and post observational periods among the four facilities ($X^2<7.23$, df=3, P>0.05). Only at Homosassa Springs State Park did more affiliative contacts occur before than after feeding (Appendix G).

Sender-receiver tables based on agonistic encounters could not be constructed because of the rarity of these contacts. Matrices were created using affiliative contacts. Manatees' interactions will be discussed facility by facility.

*Epcot* –Walt Disney World's Living Seas at Epcot Center housed two female manatees, Lydia and Mariah. A total of 43 affiliative contacts (14.3±3.9 contacts per day) occurred between these 2 manatees and all interactions occurred before or after feeding. (See appendix H for type and percentages of body contacts between individuals.)

*Homosassa* – Homosassa Springs State Park housed nine female manatees: Amanda, Ariel, Betsy, Electra, Holly, Lorelei, Oakley, Rosie, and Willoughby. A total of

31 affiliative contacts (10.3±0.3 contacts per day) occurred between the manatees, all before and after feeding. Eighteen contacts were made between 3 related individuals (Betsy, Amanda, and Ariel) consisting of a mother and her two daughters, while the remaining 6 manatees made 12 contacts to each other, with only 1 contact made between the 2 groups of manatees (Table 1). (See appendix H for type and percentages of body contacts between individuals.)

*Lowry* –Lowry Zoological Park housed two female manatees, Cinco and B.B. and one male calf, Lowry. A total of 83 contacts occurred between the manatees at Lowry; nine were aggressive (10.8%, 3.0±2.0 contacts per day) and 74 were affiliative (89.2%, 24.7±2.8 contacts per day). All contacts occurred before or after feeding. Lowry initiated the most affiliative contacts (a total of 38), B.B. initiated 20 contacts, and Cinco made 16 contacts. B.B. made more aggressive contacts than the other manatees with five contacts (55.6%). Both Cinco and Lowry made two aggressive contacts (22.2%) towards each other (Table 2). Excluding the juvenile male Lowry from total contacts, B.B. initiated contact with Cinco eight times and Cinco contacted B.B. nine times. (See appendix H for type and percentages of body contacts between individuals.)

*Sea World* –Sea World of Florida housed four adult female manatees: Charlotte, Rita, Sara, and Stubbie and two male calves: Brooks and Pistachio. A total of 71 interactions occurred over three days of observations between the manatees at Sea World, 70 (98.6%, 23.3±2.9 contacts per day) were affiliative and one (1.4%, 0.3±0.3 contacts per day) was aggressive. All contacts occurred before or after feeding. The juvenile males initiated more contacts than the adult females (initiating 52 out of the total 71 contacts). Excluding the juvenile males from total contacts, Charlotte and Sara accounted for 11 of the 13 encounters (Table 3). (See appendix H for type and percentages of body contacts between individuals.)

A total of 218 affiliative contacts were recorded at the four facilities [43 contacts at Epcot (with 206,000 gallons of water), 31 contacts at Homosassa (with approximately 3 million gallons of water), 74 at Lowry Zoological Park (with 125,000 gallons of water), and 70 at Sea World (with 375,000 gallons of water)]. I observed 10 agonistic contacts (1 at Sea World and 9 at Lowry). All manatees, with the exception of one, were involved in some type of interaction with other individuals. All interactions occurred before or after feeding; none occurred in the "during" feeding observational period. When juveniles were present at a facility (Lowry Zoological Park and Sea World), they accounted for the highest number of initiated contacts.

The total number of contacts increased significantly with the density of manatees ($R^2$=0.95, $F_{1,2}$=0.024, Figure 1). The index of dispersion was calculated using the contacts initiated by manatees at the three facilities with three or more manatees. At Homosassa and Lowry the index of dispersions were within the range of chi-square values for a Poisson Distribution (3.27 and 8 df for Homosassa; 5.57 and 2 df for Lowry), implying that the frequency of contacts occurred randomly. However, at Sea World the index of dispersion was 14.49 (5 df), suggesting a non-random, aggregation of contacts ($P<0.05$). Yet, even for Homosassa and Lowry, the contacts were not distributed equally among manatees (Tables 1 and 2).

**Discussion**

Close confinement of captive manatees did not appear to lead to problems because little aggression was observed (10 out of 228 contacts were agonistic in nature). Manatees appeared to cope with the confines of their environment and other manatees by developing some social structures, but especially regular interactions with certain individuals. Captive manatees living in groups at the facilities were able to co-habitat without aggression or territoriality. The ability of manatees to get along in captivity suggests that manatees in the wild might also interact with other manatees through affiliative encounters. This could benefit the animals because it would allow all individuals access to resources such as food, mates and space equally, especially if the resources were limited. Avoiding conflicts in the wild could also benefit manatees because it would reduce potential injuries.

Manatees in captivity formed associations through affiliation and not aggression. High number of interactions were observed between certain manatees at all facilities. At Homosassa, greater association was apparent with the separation of two social subgroups. A total of 31 contacts were made at Homosassa. Eighteen (54.8%) of those contacts were made between Amanda, Ariel, and Betsy. Betsy is the mother of Amanda and Ariel. Most contacts would be expected between related individuals as seen with these three manatees. These three individuals only contacted the other six manatees one time. In contrast, the remaining six manatees exhibited 12 contacts within this group and no contacts to Betsy, Amanda, and Ariel. Sea World of Florida housed two juvenile males under the age of two and half (Brooks and Pistachio). The young males initiated a majority of the contacts (52 out of 71 total contacts, 73.2%). Brooks made 34 contacts with most directed towards Charlotte (15) and Sara (13). Brooks' encounters primarily were play mounting with the two females. Pistachio initiated four similar contacts each to Sara, Rita, and Stubbie. At Sea World, 13 contacts were made between the adult females if the contacts made and received by the juvenile males are excluded. Of those contacts, 11 occurred between Charlotte and Sara. There appeared to be a regular association between these two manatees. Rita might be considered on the periphery of this pair. At Lowry Zoological Park, close frequent association could be seen with the two adult females, B.B. and Cinco, who made eight and nine affiliative contacts towards each other. This was similar to the manatees at Epcot, Mariah and Lydia, who made 23 and 20 affiliative contacts towards each other. Of the ten total agonistic encounters observed, nine were recorded at Lowry Zoological Park mainly towards the nine-month old male Lowry by the adult females, possibly to prevent the formation of a mother-calf bond. Lowry was born in captivity but his mother Ionia died from her injuries during rehabilitation and Lowry was introduced to the two adult females, B.B. and Cinco.

These types of associations observed with captive manatees are similar to what has been seen in Sperm whales, *Physeter macrocephaluss* (Weilgart et al. 1996) and bonobos, *Pan paniscus* (de Waal 1995). In wild manatees affiliative interactions have been observed with adult females (Koelsch 1997). Regular associations between related individuals, as observed with the three related females manatees at Homosassa, have also been observed in the wild especially among mother-calf pairs (Koelsch 1997, Reynolds and Odell 1991). Elephants, the closest living relatives to sirenians, also form bonds as well as hierarchies between related individuals. Calves are born in the wet season and the mothers are rarely seen without their calf by their side. The calf learns basic life skills from its mother and young males have even been observed play mounting with their mothers or other females within their group (Gadgil and Nair 1983). Similar play behavior towards adult female manatees was observed with juvenile males at Sea World. In the wild, juveniles seem to be submissive to adult manatees (Hartman 1979). This may help explain why the greatest numbers of agonistic encounters were seen with the juvenile male, Lowry, by the two adult females.

The number of affiliative contacts between captive manatees was used to establish sender-receiver tables. No jostling for position to eat or for remaining food scraps was observed while manatees were eating. The absence of aggressive interactions around feeding suggested that there was no competition over food in contrast to expectations. Manatees did not appear to be completely satiated at the end of feeding the period. They would consume small pieces of lettuce and readily eat again only a few hours later. Food may not have been limiting for much of the feeding period, but even as food levels decreased, aggressive interactions were not displayed. Manatees may either avoid potential conflicts or use non-aggressive interactions to mediate competitive encounters. High numbers of affiliative contacts have been observed in other captive animals including bonobos, *Pan paniscus* (de Waal 1995) and spotted hyenas (Glickman et al.

1997), which established dominance among certain individuals. Captive bonobos and hyenas were able to resolve conflicts between individuals through affiliation.

The number of manatees per unit volume of aquarium space (density) appeared to explain a large portion of the variance in the number of contacts among manatees (Figure 1). This could indicate that the number of contacts at the facilities occurred randomly simply as a factor of the number of manatees in an aquarium. However, the contact data took into account sender-receiver patterns and the test for a Poisson Distribution indicated that the contacts were not completely random for Homosassa. At Homosassa there were subgroups of manatees that touched each other more frequently than others. Of the 31 total contacts observed at Homosassa, 18 occurred between the three related females, Amanda, Ariel, and Betsy. The remaining six manatees never initiated a contact to these three females. Contacts at Sea World and Lowry were not different from random (Poisson), possibly because of the low sample size. Inspection of the sender-receiver interactions at these facilities gives the indication that contacts were not equal among pairs of individuals. Social subgroups may exist among the manatees at these facilities as well.

Koelsch (1997) suggested that manatees may be more social than previously thought. The results of this study lend some credence to this idea. However, density effects must be considered when assessing the frequency of contacts among manatees. For example, manatees may exhibit greater rates of contact in winter refugia then they would while out foraging or at other times of the year under lower density situations. In addition, the presence of juveniles will effect the rate and type of contacts (e.g., Hartman 1979). Examining the frequency of contacts at the same facility before and after manatee introductions or removals, as well as additional field studies, would improve our understanding of the social nature of the Florida manatee.

**Tables and Figures**

Table 5: Matrix constructed from affiliative contacts at Homosassa Springs State Park with nine adult females

| | Aman-da | Rosie | Betsy | Ariel | Holly | Will | Oak-ley | Lore-lei | Elec-tra | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Amanda | - | 0 | 2 | 7 | 0 | 0 | 0 | 1 | 0 | 10 |
| Rosie | 0 | - | 0 | 0 | 1 | 1 | 2 | 0 | 3 | 7 |
| Betsy | 3 | 0 | - | 2 | 0 | 0 | 0 | 0 | 0 | 5 |
| Ariel | 2 | 0 | 2 | - | 0 | 0 | 0 | 0 | 0 | 4 |
| Holly | 0 | 0 | 0 | 0 | - | 1 | 0 | 0 | 1 | 2 |
| Will | 0 | 0 | 0 | 0 | 0 | - | 1 | 0 | 0 | 1 |
| Oakley | 0 | 0 | 0 | 0 | 0 | 1 | - | 0 | 0 | 1 |
| Lorelei | 0 | 0 | 0 | 0 | 0 | 1 | 0 | - | 0 | 1 |
| Electra | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 |

Table 6: Matrix constructed from affiliative contacts at Lowry Zoological Park with two adult females and one juvenile male 0.75 years of age (Lowry)

| | Lowry | BB | Cinco | Total |
|---|---|---|---|---|
| Lowry | - | 18 | 20 | 38 |
| BB | 12 | - | 8 | 20 |
| Cinco | 7 | 9 | - | 16 |

Table 7: Matrix constructed from affiliative contacts at Sea World of Florida with four adult females and 2 juvenile males two years of age (Brooks) and 1.5 years of age (Pistachio)

| | Brooks | Pistachio | Charlotte | Sara | Rita | Stubbie | Total |
|---|---|---|---|---|---|---|---|
| Brooks | - | 3 | 15 | 13 | 2 | 2 | 35 |
| Pistachio | 3 | - | 1 | 4 | 4 | 4 | 16 |
| Charlotte | 1 | 0 | - | 8 | 0 | 0 | 9 |
| Sara | 2 | 0 | 3 | - | 0 | 0 | 5 |
| Rita | 0 | 0 | 1 | 1 | - | 0 | 2 |
| Stubbie | 1 | 0 | 0 | 0 | 0 | - | 1 |

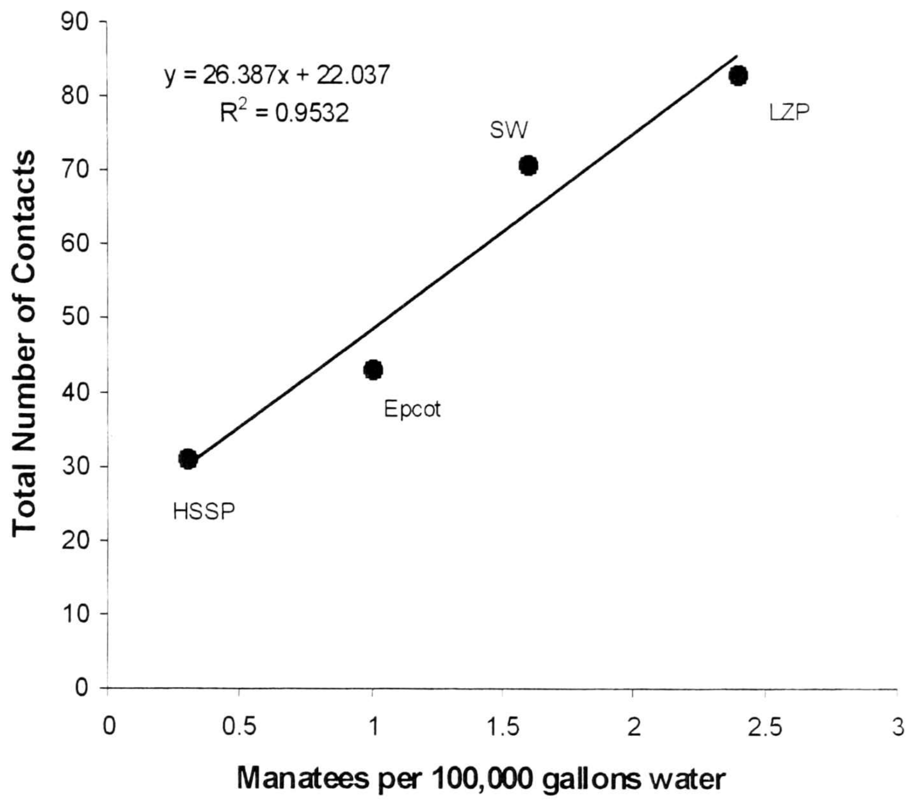


Figure 6: Number of contacts for each facility (Homosassa Springs State Park, Walt Disney World's Living Seas at Epcot Center, Sea World at Florida, and Lowry Zoological Park) initiated by manatees per 100,000 gallons of water within each aquarium.

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# Chapter IV

## Summary

The Florida manatee, *Trichechus manatus latirostris*, was studied to investigate the influence of captivity on behavior, particularly on activity patterns and social interactions. The first part of this study examined if the length of time spent in captivity affected behavior of manatees using four behavioral categories (swim, feed, inactive and miscellaneous). However, before manatees could be considered a single sample population, other variables including facilities, sex and seasons were investigated to determine if they influenced the behavior of captive manatees. There was no facility effect on swim or inactive behavioral categories for summer 2000, but there was a difference found in feed and miscellaneous behaviors. There was no facility effect for swim, inactive, or miscellaneous behaviors in winter 2001, but there was a difference for the feed behavioral category. No differences in pair-wise comparisons of facilities were evident with the behavioral categories. Activity patterns of manatees did not differ by sex or season. The length of time spent in captivity by manatees did not have a significant effect on their behavior.

Social interactions were investigated for the second part of this study to determine how manatees placed into a captive situation with few to several individuals cope and overcome conflicts. Manatees might resolve conflict through affiliation such as bonding, formation of hierarchies, or territoriality. This part of the study examined the hypotheses that (1) manatees will rarely interact, (2) manatees will interact more under higher density situations (i.e., more manatees per unit volume of aquarium space), (3) if manatees are more social than previously thought, most interactions will be affiliative in nature, and (4) most interactions will occur just before feeding or when food is becoming depleted. A total of 228 contacts were observed, yet only ten were agonistic. Regular association was observed with certain manatees at all facilities. Behavior recorded of juveniles towards adult manatees in captivity was similar to that of some juvenile behavior observed in the wild. The relationship between density and number of contacts showed a strong relationship indicating that the number of contacts at the facilities occurred randomly. However, contact data indicated that the contacts were not completely random. At Homosassa, there did appear to be subgroups of manatees that touched more frequently than others, suggesting some sociality.

Hopefully, this study will aid in the management of manatees living in captive facilities during rehabilitation or living in captivity permanently. Information from the first part of the study could help provide facilities with feeding methods for their manatees depending on if they have potentially releasable animals or not. Facilities that provided food throughout varying times of the day may represent conditions that are similar to those for manatees in the wild during warmer seasons and in warmer waters. Manatees in the wild are not limited in their search for food during this time because they are not in danger of being exposed to cold conditions that can harm or kill them. Therefore, facilities that want their manatees to forage for longer periods of time could provide smaller proportions of food more often throughout the day or disperse the food. Providing fewer and longer feeding periods may represent a pattern of feeding that more closely resembles foraging behavior seen with manatees in northern and gulf waters of Florida during the cooler seasons of the year. Manatees are restricted to warmer areas such as springs and more southern waters during this time and can only leave these protected areas for short intervals to search for food without being threatened by the cold.

Most manatees that are brought into captivity for rehabilitation are candidates for release back into the wild after their injuries are healed or they are no longer ill. Management implications based on the information from this study may aid in the release of captive manatees. If their behavior remains relatively unaffected from the wild into captivity, then the length of time spent in captivity may not be an important factor when determining if an animal is releasable or not. While manatees are in captivity, it is also important to observe social interactions because it allows animal caretakers the ability to establish a baseline for normal behaviors exhibited by the animals. Regular monitoring of social behavior in captive animals can help caretakers more easily detect and prevent potential problems. Understanding behavior and social interactions of captive manatees are important components in the rehabilitation of wild animals and in the long-term care of animals living in captivity permanently that will help educate many people on the plight of the manatee.

APPENDICES

Appendix A: Proportion of Scans (X ± SE) Spent in the Pre-Observational Period at Six Facilities Observed in Summer 2000 (-- represents behavior not observed)

| Behavior | Epcot | Homo-sassa | Lowry | Mote | Sea-quarium | Sea World |
|---|---|---|---|---|---|---|
| **Swim** | **0.38±0.09** | **0.40±0.06** | **0.35±0.13** | **0.49±0.05** | **0.39±0.09** | **0.36±0.06** |
| **Feed** | **0.06±0.00** | **0.00±0.00** | **0.00±0.00** | **0.01±0.00** | **--** | **0.02±0.00** |
| Feed Bottom | -- | -- | 0.00±0.00 | -- | -- | -- |
| Feed Top | 0.05±0.00 | 0.00±0.00 | -- | 0.01±0.00 | -- | 0.02±0.00 |
| Prepare to Grasp | 0.01±0.01 | -- | -- | -- | -- | -- |
| **Inactive** | **0.56±0.03** | **0.47±0.03** | **0.51±0.05** | **0.43±0.02** | **0.61±0.08** | **0.52±0.01** |
| Breathe | 0.06±0.00 | 0.07±0.00 | 0.07±0.02 | 0.05±0.02 | 0.07±0.01 | 0.05±0.01 |
| Float | 0.45±0.12 | 0.22±0.03 | 0.17±0.04 | 0.25±0.06 | 0.41±0.11 | 0.39±0.04 |
| Rest | 0.02±0.02 | 0.10±0.03 | 0.20±0.08 | 0.13±0.07 | 0.13±0.05 | 0.07±0.01 |
| Sleep | 0.03±0.03 | 0.08±0.03 | 0.07±0.05 | -- | -- | 0.01±0.01 |
| **Misc.** | **0.00±0.00** | **0.06±0.00** | **0.12±0.01** | **0.07±0.00** | **0.00±0.00** | **0.11±0.01** |
| Nibble | -- | 0.00±0.00 | 0.03±0.02 | -- | -- | 0.04±0.02 |
| Nuzzle | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.07±0.01 | 0.00±0.00 | 0.01±0.00 |
| Push | -- | 0.01±0.00 | 0.01±0.01 | -- | -- | -- |
| Roll | -- | 0.02±0.01 | 0.01±0.01 | -- | 0.00±0.00 | -- |
| Rub | -- | 0.02±0.01 | 0.05±0.04 | -- | -- | 0.03±0.03 |
| Upside Down | -- | 0.01±0.00 | 0.02±0.01 | 0.00+0.00 | 0.00±0.00 | 0.03±0.01 |

Appendix B: Proportion of Scans (X ± SE) Spent in the During Observational Period at Six Facilities Observed in Summer 2000 (-- represents behavior not observed)

| Behavior | Epcot | Homo-sassa | Lowry | Mote | Sea-quarium | Sea World |
|---|---|---|---|---|---|---|
| **Swim** | **--** | **0.03±0.01** | **0.07±0.01** | **0.04±0.04** | **0.05±0.02** | **0.13±0.01** |
| **Feed** | **0.81±0.05** | **0.84±0.03** | **0.75±0.05** | **0.89±0.18** | **0.89±0.04** | **0.75±0.03** |
| Feed Bottom | 0.81±0.00 | -- | 0.46±0.04 | 0.21±0.20 | 0.02±0.02 | 0.13±0.02 |
| Feed Top | -- | 0.78±0.01 | 0.22±0.06 | 0.68±0.15 | 0.87±0.05 | 0.61±0.02 |
| Prepare to Grasp | -- | 0.06±0.01 | 0.07±0.01 | -- | -- | 0.01±0.00 |
| **Inactive** | **0.19±0.03** | **0.12±0.02** | **0.13±0.01** | **0.00±0.00** | **0.05±0.00** | **0.12±0.01** |
| Breathe | 0.18±0.01 | 0.10±0.01 | 0.05±0.01 | 0.00±0.00 | 0.02±0.01 | 0.03±0.01 |
| Float | 0.01±0.01 | 0.01±0.01 | 0.03±0.02 | 0.00±0.00 | 0.02±0.01 | 0.09±0.02 |
| Rest | -- | 0.01±0.00 | 0.04±0.03 | -- | 0.01±0.00 | 0.00±0.00 |
| Sleep | -- | 0.00±0.00 | 0.01±0.01 | -- | -- | -- |
| **Misc.** | **--** | **0.00±0.00** | **0.06±0.00** | **0.00±0.00** | **0.00±0.00** | **0.00±0.00** |
| Nibble | -- | -- | 0.01±0.00 | -- | -- | 0.00±0.00 |
| Nuzzle | -- | -- | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| Push | -- | -- | 0.01±0.00 | -- | -- | -- |
| Roll | -- | 0.00±0.00 | 0.01±0.01 | -- | -- | 0.00±0.00 |
| Rub | -- | -- | 0.02±0.02 | -- | -- | 0.00±0.00 |
| Upside Down | -- | -- | 0.01±0.00 | -- | -- | 0.00±0.00 |

Appendix C: Proportion of Scans (X $\pm$ SE) Spent in the Post-Observational Period at Six Facilities Observed in Summer 2000 (-- represents behavior not observed)

| Behavior | Epcot | Homo-sassa | Lowry | Mote | Sea-quarium | Sea World |
|---|---|---|---|---|---|---|
| **Swim** | **0.20±0.02** | **0.46±0.06** | **0.28±0.10** | **0.29±0.04** | **0.34±0.10** | **0.42±0.04** |
| **Feed** | **0.13±0.00** | **0.01±0.00** | **0.21±0.03** | **0.20±0.02** | **0.02±0.00** | **--** |
| Feed Bottom | 0.03±0.01 | -- | 0.14±0.09 | 0.10±0.05 | -- | -- |
| Feed Top | 0.09±0.01 | 0.01±0.01 | 0.04±0.01 | 0.08±0.03 | 0.02±0.01 | -- |
| Prepare to Grasp | 0.01±0.00 | -- | 0.03±0.02 | 0.02±0.00 | -- | -- |
| **Inactive** | **0.65±0.03** | **0.45±0.02** | **0.48±0.05** | **0.48±0.02** | **0.63±0.08** | **0.57±0.01** |
| Breathe | 0.10±0.01 | 0.08±0.01 | 0.07±0.01 | 0.11±0.02 | 0.07±0.01 | 0.05±0.00 |
| Float | 0.50±0.05 | 0.18±0.03 | 0.12±0.04 | 0.20±0.03 | 0.39±0.11 | 0.38±0.02 |
| Rest | 0.03±0.02 | 0.12±0.04 | 0.20±0.07 | 0.17±0.02 | 0.17±0.05 | 0.12±0.02 |
| Sleep | 0.02±0.02 | 0.07±0.05 | 0.09±0.05 | -- | -- | 0.02±0.01 |
| **Misc.** | **--** | **0.08±0.00** | **0.03±0.00** | **0.03±0.00** | **0.01±0.00** | **0.01±0.00** |
| Nibble | -- | -- | 0.00±0.00 | -- | -- | -- |
| Nuzzle | -- | -- | 0.00±0.00 | 0.02±0.00 | 0.00±0.00 | 0.00±0.00 |
| Push | -- | 0.01±0.00 | 0.00±0.00 | -- | -- | -- |
| Roll | -- | 0.06±0.04 | 0.02±0.01 | -- | 0.00±0.00 | 0.00±0.00 |
| Rub | -- | 0.01±0.01 | 0.00±0.00 | -- | -- | 0.01±0.01 |
| Upside Down | -- | -- | 0.01±0.01 | -- | 0.00±0.00 | 0.00±0.00 |

Appendix D: Proportion of Scans (X ± SE) Spent in the Pre-Observational Period at Five Facilities Observed in Winter 2001 (-- represents behavior not observed)

| **Behavior** | **Epcot** | **Homosassa** | **Lowry** | **Seaquarium** | **Sea World** |
|---|---|---|---|---|---|
| **Swim** | **0.19±0.13** | **0.43±0.05** | **0.41±0.03** | **0.44±0.08** | **0.41±0.07** |
| **Feed** | -- | -- | -- | -- | -- |
| Feed Bottom | -- | -- | -- | -- | -- |
| Feed Top | -- | -- | -- | -- | -- |
| Prepare to Grasp | -- | -- | -- | -- | -- |
| **Inactive** | **0.76±0.03** | **0.52±0.02** | **0.58±0.01** | **0.55±0.01** | **0.55±0.01** |
| Breathe | 0.10±0.00 | 0.10±0.01 | 0.04±0.01 | 0.09±0.02 | 0.10±0.01 |
| Float | 0.43±0.12 | 0.29±0.05 | 0.33±0.02 | 0.35±0.11 | 0.28±0.04 |
| Rest | 0.06±0.00 | 0.06±0.02 | 0.13±0.01 | 0.08±0.03 | 0.07±0.03 |
| Sleep | 0.17±0.00 | 0.07±0.02 | 0.08±0.04 | 0.03±0.01 | 0.10±0.04 |
| **Misc.** | **0.05±0.00** | **0.05±0.00** | **0.01±0.00** | **0.01±0.00** | **0.04±0.00** |
| Nibble | 0.02±0.01 | -- | -- | 0.00±0.00 | 0.01±0.01 |
| Nuzzle | -- | -- | -- | -- | 0.01±0.01 |
| Push | 0.01±0.00 | 0.00±0.00 | -- | -- | -- |
| Roll | -- | 0.02±0.02 | -- | 0.00±0.00 | -- |
| Rub | -- | 0.03±0.01 | -- | -- | 0.01±0.01 |
| Upside Down | 0.02±0.01 | -- | 0.01±0.01 | 0.01±0.00 | 0.01±0.00 |

Appendix E: Proportion of Scans (X ± SE) Spent in the During Observational Period at Five Facilities Observed in Winter 2001 (-- represents behavior not observed)

| **Behavior** | **Epcot** | **Homosassa** | **Lowry** | **Seaquarium** | **Sea World** |
|---|---|---|---|---|---|
| **Swim** | **0.02±0.01** | **0.07±0.02** | **0.12±0.07** | **0.09±0.01** | **0.01±0.00** |
| **Feed** | **0.84±0.01** | **0.87±0.00** | **0.71±0.02** | **0.86±0.01** | **0.96±0.02** |
| Feed Bottom | 0.84±0.01 | 0.07±0.07 | 0.26±0.06 | -- | 0.19±0.10 |
| Feed Top | -- | 0.76±0.09 | 0.41±0.10 | 0.82±0.02 | 0.73±0.10 |
| Prepare to Grasp | -- | 0.04±0.00 | 0.04±0.01 | 0.04±0.00 | 0.04+0.00 |
| **Inactive** | **0.14±0.00** | **0.05±0.02** | **0.18±0.02** | **0.05±0.01** | **0.04±0.00** |
| Breathe | 0.13±0.01 | 0.05±0.00 | 0.06±0.01 | 0.04±0.01 | 0.03±0.01 |
| Float | 0.01±0.01 | -- | 0.07±0.06 | 0.01±0.00 | 0.01±0.00 |
| Rest | -- | -- | 0.03±0.03 | -- | -- |
| Sleep | -- | -- | 0.02±0.02 | -- | -- |
| **Misc.** | **--** | **--** | **0.00±0.00** | **--** | **--** |
| Nibble | -- | -- | -- | -- | -- |
| Nuzzle | -- | -- | -- | -- | -- |
| Push | -- | -- | -- | -- | -- |
| Roll | -- | -- | -- | -- | -- |
| Rub | -- | -- | -- | -- | -- |
| Upside Down | -- | -- | 0.00±0.00 | -- | -- |

Appendix F: Proportion of Scans (X ± SE) Spent in the Post-Observational Period at Five Facilities Observed in Winter 2001 (-- represents behavior not observed)

| **Behavior** | **Epcot** | **Homosassa** | **Lowry** | **Seaquarium** | **Sea World** |
|---|---|---|---|---|---|
| **Swim** | **0.39±0.17** | **0.44±0.03** | **0.41±0.04** | **0.43±0.05** | **0.40±0.04** |
| **Feed** | **0.02±0.00** | **0.01±0.00** | **--** | **--** | **--** |
| Feed Bottom | 0.02±0.00 | -- | -- | -- | -- |
| Feed Top | -- | 0.01±0.01 | -- | -- | -- |
| Prepare to Grasp | -- | -- | -- | -- | -- |
| **Inactive** | **0.54±0.03** | **0.50±0.02** | **0.59±0.01** | **0.57±0.01** | **0.55±0.01** |
| Breathe | 0.08±0.01 | 0.10±0.01 | 0.13±0.02 | 0.09±0.01 | 0.10±0.00 |
| Float | 0.46±0.15 | 0.31±0.05 | 0.28±0.01 | 0.32±0.09 | 0.30±0.03 |
| Rest | -- | 0.06±0.02 | 0.17±0.02 | 0.11±0.04 | 0.08±0.01 |
| Sleep | -- | 0.03±0.01 | 0.01±0.01 | 0.05±0.02 | 0.07±0.02 |
| **Misc.** | **0.06±0.00** | **0.05±0.00** | **--** | **0.00±0.00** | **0.05±0.00** |
| Nibble | 0.03±0.01 | -- | -- | -- | 0.00±0.00 |
| Nuzzle | -- | -- | -- | -- | 0.02±0.01 |
| Push | 0.01±0.01 | 0.00±0.00 | -- | -- | -- |
| Roll | 0.01±0.01 | 0.02±0.02 | -- | -- | -- |
| Rub | -- | 0.03±0.01 | -- | -- | 0.02±0.01 |
| Upside Down | 0.01±0.00 | -- | -- | 0.00±0.00 | 0.01±0.00 |

Appendix G: Number of contacts over three days of observations at four different facilities

| | Epcot | Homosassa | Lowry | Sea World |
|---|---|---|---|---|
| Day 1-Pre (Agonistic) | 0 | 0 | 3 | 0 |
| Day 1-Pre (Affiliative) | 5 | 7 | 12 | 9 |
| Day 1-Post (Agonistic) | 0 | 0 | 4 | 0 |
| Day 1-Post (Affiliative) | 4 | 3 | 15 | 19 |
| Day 2-Pre (Agonistic) | 0 | 0 | 1 | 0 |
| Day 2-Pre (Affiliative) | 3 | 7 | 18 | 11 |
| Day 2-Post (Agonistic) | 0 | 0 | 0 | 0 |
| Day 2-Post (Affiliative) | 9 | 4 | 10 | 13 |
| Day 3-Pre (Agonistic) | 0 | 0 | 0 | 0 |
| Day 3-Pre (Affiliative) | 9 | 6 | 4 | 7 |
| Day 3-Post (Agonistic) | 0 | 0 | 1 | 1 |
| Day 3-Post (Affiliative) | 13 | 4 | 15 | 11 |
| Total-Pre (Agonistic) | 0 | 0 | 4 | 0 |
| Total-Pre (Affiliative) | 17 | 20 | 34 | 27 |
| Total-Post (Agonistic) | 0 | 0 | 5 | 1 |
| Total-Post (Affiliative) | 26 | 11 | 40 | 43 |
| Overall-Agonistic | 0 (0%) | 0 (0%) | 9 (10.8%) | 1 (1.4%) |
| Overall-Affiliative | 43 (100%) | 31 (100%) | 74 (89.2%) | 70 (98.6%) |
| Total Contacts | 43 | 31 | 83 | 71 |
| X±SE-Agonistic | 0.0±0.0 | 0.0±0.0 | 3.0±2.0 | 0.3±0.3 |
| X±SE-Affiliative | 14.3±3.9 | 10.3±0.3 | 24.7±2.8 | 23.3±2.9 |

Appendix H: Type of body touches and percentages of total contacts making up all affiliative contacts between individual manatees at four facilities in Florida during winter 2001 (-- indicates no contacts).

| | **Mouth** | **Fin** | **Body** | **Head** | **Tail** |
|---|---|---|---|---|---|
| **Epcot** | | | | | |
| Mariah->Lydia | 10 (43.5%) | 8 (34.8%) | 3 (13%) | 2 (8.7%) | -- |
| Lydia->Mariah | 6 (30%) | 7 (35%) | 7 (35%) | -- | -- |
| **Homosassa** | | | | | |
| Amanda->Ariel | 6 (60%) | 1 (10%) | -- | -- | -- |
| Amanda->Betsy | 1 (10%) | 1 (10%) | -- | -- | -- |
| Amanda->Lorelei | -- | -- | 1 (10%) | -- | -- |
| Betsy->Amanda | 2 (40%) | -- | 1 (20%) | -- | -- |
| Betsy->Ariel | -- | 1 (20%) | 1 (20%) | -- | -- |
| Ariel->Amanda | 1 (25%) | -- | -- | -- | 1 (25%) |
| Ariel->Betsy | 1 (25%) | -- | -- | -- | 1 (25%) |
| Rosie->Oakley | -- | -- | 2 (28.6%) | -- | -- |
| Rosie->Holly | -- | -- | 1 (14.3%) | -- | -- |
| Rosie->Electra | -- | 2 (28.6%) | -- | 1 (14.3%) | -- |
| Rosie->Will | 1 (14.3%) | -- | -- | -- | -- |
| Holly->Will | -- | -- | 1 (50%) | -- | -- |
| Holly->Electra | -- | -- | 1 (50%) | -- | -- |
| Lorelei->Will | -- | -- | 1 (100%) | -- | -- |
| Oakley->Will | -- | 1 (100%) | -- | -- | -- |
| Will->Oakley | 1 (100%) | -- | -- | -- | -- |
| **Lowry** | | | | | |
| Lowry->B.B. | 2 (5.3%) | 3 (7.9%) | -- | 15 (39.5%) | -- |
| Lowry->Cinco | 4 (10.5%) | -- | -- | 11 (28.9%) | 3 (7.9%) |
| B.B.->Lowry | -- | 3 (15%) | 4 (20%) | 5 (25%) | -- |
| B.B.->Cinco | 1 (4%) | 3 (15%) | 1 (5%) | 3 (15%) | 1 (5%) |
| Cinco->Lowry | -- | 3 (18.8%) | 1 (6.3%) | 3 (18.8%) | -- |
| Cinco->B.B. | -- | 3 (18.8%) | 1 (6.3%) | 5 (31.3%) | -- |
| **Sea World** | | | | | |
| Brooks->Sara | 6 (17.6%) | 6 (17.6%) | 1 (2.9%) | -- | -- |
| Brooks->Charlotte | 11 (32.4%) | 3 (8.8%) | -- | -- | -- |
| Brooks->Rita | 1 (2.9%) | 1 (2.9%) | 3 (8.8%) | -- | -- |
| Brooks->Pistachio | -- | -- | -- | -- | -- |

| | | | | | |
|---|---|---|---|---|---|
| Brooks->Stubbie | 2 (5.9%) | -- | -- | -- | -- |
| Pistachio->Sara | 2 (11.1%) | 2 (11.1%) | 1 (5.6%) | -- | -- |
| Pistachio->Char | -- | 2 (11.1%) | -- | -- | -- |
| Pistachio->Brooks | 1 (5.6%) | -- | 3 (16.7%) | -- | -- |
| Pistachio->Stubbie | 1 (5.6%) | 1 (5.6%) | 2 (11.1%) | -- | -- |
| Pistachio->Rita | 2 (11.1%) | -- | 1 (5.6%) | -- | -- |
| Charlotte->Sara | 5 (62.5%) | -- | -- | -- | -- |
| Charlotte->Brooks | 1 (12.5%) | -- | 2 (25%) | -- | -- |
| Sara->Charlotte | 4 (57.1%0 | -- | 1 (14.3%) | -- | -- |
| Sara->Brooks | -- | 1(14.3%) | 1 (14.3%) | -- | -- |
| Rita->Sara | 1 (50%) | -- | -- | -- | -- |
| Rita->Charlotte | -- | 1 (50%) | -- | -- | -- |
| Stubbie->Brooks | -- | -- | 1 (100%) | -- | -- |
| **TOTALS** | **73 (33.5%)** | **52 (23.9%)** | **42 (19.3%)** | **45 (20.6%)** | **6 (2.8%)** |